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REPORT

ON THE

GAS NUISANCE

IN NEW YORK.

BY

C. F. CHANDLER, PH. D.,

PROFESSOR OF ANALYTICAL AND APPLIED CHEMISTRY, SCHOOL OF MINES, COLUMBIA COLLEGE.

[*EXTRACT FROM THE FOURTH ANNUAL REPORT OF THE METROPOLITAN BOARD OF HEALTH.*]

NEW YORK:
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THE GAS NUISANCE.

REPORT OF THE CHEMIST OF THE BOARD ON GAS PURIFICATION, WITH A HISTORY OF THE GAS NUISANCE IN NEW YORK.

COLONEL EMMONS CLARK, *Secretary of the Metropolitan Board of Health.*

SIR: In answer to the resolution of the Board of Health, directing the Chemist to make a statement *in extenso* of the methods of purification employed by the several gas companies of New York, I have the honor to submit the following report:

I.—METHODS OF PURIFICATION IN GENERAL USE.

The crude gas which is produced by the exposure of bituminous coal to a bright-red heat, in clay or iron retorts, is freed, during its passage through the hydraulic main, the condenser, and the washer, from the tar which it contains, and from a portion of its water and ammoniacal compounds. It still contains, however, objectionable impurities, which must be removed by a process of purification. These are sulphuretted hydrogen, sulphide of ammonium, cyanide of ammonium, sulphocyanide of ammonium, bisulphide of carbon, certain other sulphur compounds whose exact nature is not known, and carbonic acid. The sulphur compounds are all very objectionable; they give the gas a very offensive smell, and when burned produce sulphurous acid, which, if evolved in any considerable quantity, would quickly render the air of a room unfit for human life, and seriously injure furniture and goods exposed to its action. These sulphur compounds must, therefore, be removed. The carbonic-acid gas is objectionable only in so far as it diminishes the illuminating power of the gas when present in appreciable quantities. There is no sanitary objection to carbonic acid; for perfectly-purified gas would produce, when burned, a great many times as much carbonic acid as exists in the most impure crude gas. The presence of ammonia in gas in appreciable quantities is objectionable; but as all the methods of purification, at present used, remove the compounds of ammonia very effectually, we may confine the discussion to the sulphur compounds and the carbonic acid. There are four methods of purifying gas now in use.

1. *The Wet-Lime Process.*

This process involves passing the gas through milk of lime. It is the oldest process in use, and is very effective in removing both the sulphur compounds and the carbonic acid. It has been generally abandoned, however, on account

of the difficulty of disposing of the foul milk of lime, called "blue billy." Occurring as a liquid, the "blue billy" is not easily transported; and as it does not rapidly undergo oxidation, it is not well adapted for use as a fertilizer. Running it into rivers and streams has been forbidden by law, as the pollution of the waters by it was intolerable, while the extremely offensive smell which it emits makes it impossible to store it until it becomes dry enough for transportation.

2. *The Dry-Lime Process.*

In this process dry or slightly-moist hydrate of lime is placed on trays in iron boxes, through which the gas is made to pass. This process is very effective, and has very generally superseded the wet-lime process. It removes the sulphur compounds and the carbonic acid equally well. When the foul lime is removed, however, it evolves the same odor which caused the wet-lime process to be abandoned. When exposed to the air it rapidly undergoes oxidation, becoming heated in consequence. During this process it evolves sulphide of ammonium, and some other compounds whose exact nature is not known, but whose odor is extremely offensive. This is the cause of the "gas nuisance" so loudly complained of a few years ago, when all the New York companies employed this process of purification. After the oxidation of the foul lime is completed it ceases to be specially offensive, the peculiar stench being evolved during the first hour or two of exposure. The offensiveness of this foul lime became such a constant cause of complaint in the large cities of Europe that the gas companies were compelled to abandon the process, as they had previously abandoned the wet lime. A system of ventilating the foul lime has been invented and is now in use at both the stations of the Manhattan Company in this city, which effects its oxidation in such a manner that the offensive gases evolved are not permitted to escape into the atmosphere, but are passed through a washing apparatus and finally through a special purifier, by which they are rendered comparatively inoffensive. This invention seems to obviate the nuisance of dry-lime purification.

3. *The Laming Process.*

In 1849 Mr. Laming introduced the hydrated sesquioxide of iron as a substitute for lime for purifying gas, preparing it of a suitable quality by mixing copperas (sulphate of iron) with slacked lime and sawdust, and exposing the mixture to the air to oxidize the protoxide of iron to the sesquioxide. The resulting mixture contains hydrated sesquioxide of iron, sulphate of lime, and sawdust.

When an excess of hydrate of lime is employed the resulting mixture contains this substance also. This material is very effective in removing the sulphur compounds from the gas. There is, however, some difference of opinion as to the completeness with which the carbonic acid is removed, due perhaps to variations in the proportions of the ingredients. Two important advantages attend the use of this mixture; first, when fouled it does not evolve offensive odors on exposure to the air; second, by exposure to air the sesquioxide of iron, which has been changed to sulphide of iron in the purifier, is regenerated, the sulphur being liberated and sesquioxide of iron again formed. The mixture

may therefore be used again and again, till it becomes so clogged with the sulphur liberated that it does not act promptly on the gas. It is then found to contain from forty to sixty per cent. of sulphur, and may be used for the manufacture of sulphuric acid. I have seen mixtures which had been in use twelve months.

4. *The Iron-Ore Process.*

A few months after Laming introduced the artificial hydrated sesquioxide of iron in France, Mr. J. M. Hills applied the natural hydrated sesquioxide of iron, or "bog-iron ore," in England. This material, like the Laming mixture, may be used again and again, and does not evolve offensive odors when exposed to the air. A modification of this process is now used by the New York Gas-light Company of this city. It was invented by Messrs. St. John and Cartwright, and has been in use nearly two years, giving entire satisfaction. As the bog-iron ores of this neighborhood are not sufficiently pulverulent to act promptly on the gas, Messrs. St. John and Cartwright add to the ore a quantity of iron borings or turnings, which they then convert into an artificial hydrated sesquioxide of iron by moistening the whole with ammoniacal liquor and exposing it to the air. The resulting mixture of natural and artificial oxide receives an addition of coarsely-pulverized charcoal. This mixture is always sprinkled with ammoniacal water before it is placed in the purifier.

The material now in daily use at the works of the New York Gas-light Company was introduced in April, 1868. Occasional additions of iron borings have been made to it; otherwise the material is the same. When last tested it contained thirty per cent. of sulphur. In Germany several varieties of sesquioxide of iron are now in use, prominent among which are "the Oberuseler mixture," an iron-ore containing some oxide of manganese; the "Manheim oxide," and "Deicke's oxide," very pure artificial oxides of iron.

II.—EXTENT TO WHICH THE DIFFERENT METHODS OF PURIFICATION ARE EMPLOYED.

The wet-lime method has been almost entirely abandoned. The only works at which I know it to be used at present are at Cork, in Ireland. These works are of moderate size, and are situated out of the city. Moreover, the gas is freed from ammonia by means of sulphuric acid, before it comes in contact with the lime. The foul lime does not, therefore, evolve sulphide of ammonium when exposed to the air. The dry-lime process, though still in general use in this country, has been almost universally abandoned in Europe. Abandoned, firstly, because the foul lime was an intolerable nuisance; secondly, because the process is too expensive, as the lime can be used but once, and when exhausted has but a trifling value as a fertilizer.

The Laming mixture is now used in many of the European gas-works. All the gas supplied to Paris is purified by this material. The German gas engineers have found that this mixture owes its efficacy entirely to the oxide of iron which it contains, and that the sulphate and hydrate of lime present do not take any appreciable part in the purification. Hence they are abandoning this mixture for the natural or artificial oxides of iron, which are cheaper and more efficient.

The iron-ore method is now most generally used in Europe, and has obtained a foothold in this country, being used by the New York Gas-light Company in this city, as already described, and by two or three companies in Massachusetts. All the Liverpool gas; much, if not all, of the London gas, and that of most of the German cities, is now purified either by iron-ore or one of the artificial oxides of iron. As my statements with regard to the general use of iron in place of lime were called in question during the hearing before the Board of Health, I will state that they were fully confirmed by my observations in Europe during the past summer, and will quote two or three unimpeachable authorities. Dr. Schilling, director of the gas-works at Munich, and editor of the *Journal für Gasbeleuchtung*, says on page 247 of that journal for 1868: "Iron purification is now in general use." Mr. A. Buhe, who was one of the chemists employed by the German Gas Association to investigate the whole subject of gas purification, says, in the above-mentioned journal for 1868, page 327 *et sequitur*: "Gas engineers have sought by various means, especially by lime, to remove the carbonic acid from gas; but these have been generally abandoned on account of the cost and the numerous disadvantages which attend their use." .... "Purification by lime is hardly in use at the present time." Mr. G. R. Hislop, Engineer and Manager of the Paisley Gas Works, and President of the North British Association of Gas Managers, stated in his address at Glasgow, July 28, 1869: "Purification by lime in London and elsewhere has now become inadmissible; in such places oxide of iron is employed as the purifying agent."—(*Journal of Gas-Lighting*, 1869, p. 695.)

III.—COMPARATIVE ADVANTAGES OF THE DIFFERENT METHODS.

The lime methods effectually remove the carbonic acid, and reduce the sulphur compounds to a minimum. Were there no objections to the use of dry lime on the score of cost or offensiveness, I think this agent would be generally preferred. Lime was first abandoned on account of the nuisance which it occasioned, but the iron oxides are now actually preferred by the European gas-engineers on account of their greater economy. Mr. King, the engineer of the Liverpool works, assured me that the oxide-of-iron purification, which he had used exclusively for the past seven or eight years, cost less than half as much as the dry-lime process used previously.

Two objections are urged against the iron methods by those who are prejudiced in favor of lime. First, they do not remove carbonic acid; second, it is claimed that they do not remove the sulphur compounds as completely as lime.

The first is generally conceded to be true. But the only objection to carbonic acid is that it reduces the illuminating power of the gas. One per cent. of carbonic acid diminishes the illuminating power five per cent. The average quantity of carbonic acid is, say, two and one-half per cent.; then the illuminating power of the gas will suffer to the extent of twelve and one-half per cent., or one-eighth.

There are two ways in which this difficulty can be effectually met: First, by using better coals for making the gas, or adding a few pounds of rich cannel or some other enriching material to the ordinary gas-coals; or secondly, by taking less gas from the coal. The last gas drawn from the coal is always inferior to

that which comes off first. Mr. A. Buhe, already referred to, says: "It has become more and more the custom to leave the carbonic acid in the gas, and to neutralize its bad influence on the illuminating power by taking less gas from the coal, thus getting a better gas." Dr. Schilling says: "Carbonic acid is of no consequence to the consumer; cannel coal is the remedy."

The second objection to the iron processes is the alleged imperfect removal of the sulphur compounds. None of the methods in use entirely remove the sulphur from the gas. The question arises, therefore, how much sulphur can be safely left in the gas. The English Parliament has answered this question by fixing the limit at twenty grains of sulphur to one hundred cubic feet of gas; and, to see that the companies come within this limit, chemists are appointed whose duty it is to analyze the gas and to report its quality. I have before me the report of Dr. Letheby for the months of January, February, and March, 1869. He states the grains of sulphur found in one hundred cubic feet of gas to be as follows:

	Maximum.	*Minimum.*	*Average.*
City of London Gaslight and Coke Company.	18.92	11.70	15.00
The Gaslight and Coke Company.....	24.15	15.75	19.49
Great Central Gas Consumers' Company.....	24.00	7.03	12.28

From this, it will be seen that the gas of London, although purified by iron, does not average twenty grains of sulphur in one hundred cubic feet. With regard to the Paris gas which is purified by Laming's oxide-of-iron mixture, Prof. J. Lawrence Smith, one of the United States Commissioners to the French Exposition of 1867, who is the president of the Louisville Gas Company, has given us a very decided opinion. On page 88 of his report, which was published by the United States Government, he says: "The gas of these works is most thoroughly purified, and the dealers in silks and other delicate fabrics who, a few years ago, always suffered more or less loss from the results of the combustion of impure gas acting on their fabrics, now no longer suffer from this cause."

Dr. Letheby (*Journal of Gas-Lighting*, 1869, page 83) has argued that twenty grains of sulphur should not be left in the gas, and proposes, therefore, as the most effective method of purifying gas, this treatment: first, with ammoniacal liquor; second, with hydrated oxide of iron; third, with dry lime. As the iron will have removed the sulphuretted hydrogen, the refuse lime will not be offensive, while it will effectually remove the carbonic acid. This system of purification will, he thinks, reduce the quantity of sulphur to ten or twelve grains per one hundred cubic feet. Most gas engineers and chemists differ from Dr. Letheby on this point, however. Dr. Schilling says, in his *Journal für Gasbeleuchtung* for 1869, page 484: "Twenty grains of sulphur in one hundred cubic feet of gas are entirely unobjectionable. Under the most favorable circumstances, with no ventilation whatever, it would give the atmosphere of a room only one part of sulphurous acid in 500,000 parts of air." Prof. William Odling, secretary of the London Chemical Society, has spoken very clearly on this subject in his lecture to the British Association of Gas Managers, June 2, 1868, which appears in the *Journal of Gas-Lighting* for 1869, page 81,

and I have found that his views are those generally entertained by chemists and gas engineers. He said:

"I am altogether at issue with the public when they maintain that the sulphur of gas produces, by its combustion, oil of vitriol, or that the amount of sulphur ordinarily contained in gas, is of any consequence whatever; and a little consideration will, I think, satisfy you of the soundness of this position. We will assume that coal-gas contains not twenty, but forty grains of sulphur in 100 feet, a quantity, at any rate, greatly exceeding the reality. Now, making another extravagant assumption that the whole of these forty grains of sulphur would be completely burned, and, in reality, they would be burned very incompletely, they would furnish, by their combustion, eighty grains of sulphurous-acid gas. This quantity of the produced sulphurous acid would occupy, at ordinary temperatures, about one-fifteenth part of a cubic foot, and since 100 cubic feet of our coal-gas gives one-fifteenth of a cubic foot of sulphurous acid, 1,500 cubic feet of coal-gas would be required to furnish one cubic foot of the acid, even upon the extravagant assumptions we have purposely made. But the combustion of 1,500 feet of coal-gas would produce something besides sulphurous acid. It would produce at least 1,000 cubic feet of carbonic acid, and, in addition to its dilution by other gases and vapors, we should have our sulphurous acid diluted by 1,000 times its volume of carbonic acid. Now, if we can get at the proportion of carbonic acid in the atmosphere of a room highly illuminated with gas, and take the thousandth part of that proportion, we shall be able to form some notion of the amount of sulphurous acid present. You will remember that the amount of carbonic acid furnished by the breath of one individual is equal to that furnished by two three-feet gas-burners, and that the maximum amount of carbonic acid found in the atmosphere of a crowded theatre was 0.32 per cent. Now, if in addition to our previous unreasonable suppositions we further suppose that an atmosphere contains 0.2 per cent. of carbonic acid furnished by gas combustion, you will see that the whole matter becomes a *reductio ad absurdum;* that we might actually have one-half-millionth part of sulphurous acid present in the air of a gas-lighted room."

I think that the facts and opinions here quoted effectually dispose of the second objection to oxide-of-iron purification. It may seem that I have said more than was necessary on the comparative merits of the lime and iron processes of purification, but a perusal of the testimony given during the hearing before the Board will recall the fact that the evidence of the experts, called by the Metropolitan Gaslight Company, was almost entirely confined to this question. In fact, the defence offered was the alleged total failure of the iron processes, and the consequent unavoidable use of lime.

IV.—HISTORY OF THE GAS NUISANCE.

For years the citizens of New York have complained of a peculiarly offensive smell which was perceived throughout the city to a greater or less degree, according to the weather. This smell was noticed at particular hours of the day, and pervaded large districts, making it impossible to open the windows during its prevalence. By many this smell was attributed to the gases from the sewers, but it was easily demonstrated that the sewers did not, as they do

not now, send out offensive gases. The enormous quantities of Croton water used throughout the city make it impossible for the sewers ever to become specially offensive. The smell was peculiar, and was recognized at once by every chemist, and by every one familiar with the manufacture of gas, as the smell of the foul lime which had been used for purifying gas.

The first special complaint against a gas company that I find on record, is that of Dr. E. H. Janes to the Board of Health, against the Manhattan Company, dated April 24, 1866, and printed in the annual report of the Board for that year. The subject was at that time referred to the Sanitary Committee. On the 30th of April following, a committee of the Citizens' Association conferred with the Sanitary Committee on the subject; Prof. R. O. Doremus and Prof. Samuel St. John appearing as members of the citizens' committee, and the gas companies being represented by some of their officers. As a result of this conference, the Manhattan and New York companies at once turned their attention to the subject, and sought means to prevent the nuisance which they admitted to exist. Nor were their efforts in vain. The Manhattan Company made a number of experiments with a view to destroying the foul gases of the refuse lime, and finally introduced the ventilating process which I have already alluded to, and which, with the improvements recently introduced, seems to effectually remedy the nuisance. The New York company was equally active, and after considerable investigation decided to give up lime purification altogether, and very judiciously introduced the oxide of iron in its place. Thus the largest companies on the island, which supply all the gas consumed below Thirty-fourth Street, promptly responded to the suggestions of the sanitary committee, and removed the cause of complaint. As these two companies manufacture four-fifths of all the gas produced on the island, and own all the gas-works situated below Forty-first Street, a great improvement was at once noticed.

The Metropolitan Company, however, which supplies gas to that portion of the city between Thirty-fourth and Seventy-ninth Streets, paid no heed to complaints of the citizens, but continued to send out the odors of foul lime. As this company does not manufacture more than one-fifth of the gas supplied to this city, the nuisance was not, however, as general as before. Its works are situated at the foot of West Forty-second Street, and the odors are often blown westward, away from the island. In certain kinds of weather, however, the smell was diffused throughout the city, and complaints were not rare. Some attempts were made to coerce the company, but all responsibility for the smell was stoutly denied by the officers. The members of the Board of Health were on the alert with a determination to compel the offending parties to follow the example of the other companies.

On July 5, 1868, Dr. Stephen Smith, Sanitary Commissioner, and Dr. Elisha Harris, Sanitary Superintendent, noticed the unmistakable smell of foul lime in Thirty-fourth Street. They consulted the neighboring vanes, and found that the wind was blowing from the northwest, and, walking in this direction, guided by the odor, they came to the Metropolitan Gas-Works in West Forty-second Street, when they found that a purifier had just been emptied, and the pile of foul lime was still warm and reeking with offensive gases. When these facts

were reported to the Board of Health, an order was at once issued, dated July 14th, declaring the manufacture of gas at the foot of West Forty-second Street to be a nuisance, and ordering the same to be discontinued, except it be conducted by a process that will not allow any delcterious gases or odors detrimental to health to escape into the external air.

Mr. Zollikoffer, the president of the Metropolitan Company, at once requested an opportunity to be heard in defence of the company; and on August 10th he appeared by counsel and showed by his witness that he employed the best coals and purified by the best process, and that the gases evolved by the foul lime were any thing but unhealthy—were, indeed, a specific for the whooping-cough and other diseases. The Attorney for the Board of Health showed by his witness that the purification as conducted by the Metropolitan Company was necessarily a nuisance, but one that could be easily avoided by following the example of either of the other city companies. The hearing was then adjourned to August 13th. On that day the counsel presented a memorial from the gas company, signed by the president. In this they first plead the inexperience of youth, the company being the youngest on the island. They then state that they never heard it even suggested that purification by dry lime was in any way offensive till they received the order of July 14th. This is a somewhat remarkable statement, inasmuch as every book on gas-making admits the nuisance, and since the other companies had, two years previously, in response to the Board of Health, investigated the matter and made the necessary changes, all the particulars having appeared in the daily papers from time to time.

Further, while they protest against the adjudication of the Board of Health that their process of purification is a nuisance, they avow their willingness to try any method which science may suggest and experiment demonstrate to be a better one than that which they are using; and finally request that the hearing be postponed till March 1, 1869, that they may experiment on improved methods of purification. The Board finally consented to a postponement of several months.

On February 6, 1869, the hearing was resumed. The gas company had enjoyed a respite of nearly six months for this special object, and on a distinct written promise to make experiments; and had not actually made a single experiment during the entire period. One thing only had been done, they sent a man to Europe to learn what processes of purification were in use there. He had returned, but great care was taken, when the hearing was resumed, not to put him on the witness-stand, for his written report was a complete confirmation of all that had been claimed by the witness for the Board of Health with regard to the improved processes of purification there and for preventing nuisance. What did the Metropolitan Company do, then, after making written promises, and saying so much about good faith, etc.? They made no experiments; did not follow the advice of the man they had sent to Europe; did not do what either of the other New York companies had done to mitigate the nuisance, but at the end of six months appeared by counsel, with distinguished chemical experts, to defend the stench-producing method of purification. For several days the hearing was continued, and nearly two hundred printed pages of testimony taken.

I will do justice to Professor Silliman, who was called to testify by the gas company, by stating that, while we differed as to the expediency of introducing iron purification instead of lime, he stated clearly and unequivocally, on the cross-examination, that the process of purification as conducted by the Metropolitan Company was necessarily a nuisance, and that by using simple precautions this nuisance could be avoided. This was all that the Board of Health was called upon to prove, and the admission of this by their own witness was evidently understood by the gas company as equivalent to losing their case. So they presented another memorial, or, rather, a set of resolutions, in which they again proposed to experiment. This was on March 4th, and the hearing was then postponed till March 22d, the company solemnly stipulating to introduce and test the iron or some other improved process.

When March 22d arrived, the company again made excuses. "In order to introduce the iron process it was necessary to place false bottoms of perforated plank in the purifiers, and there was only one man in New York who could bore the holes, and he had been busy boring holes for some one else." Still, the patience of the Board of Health held out, especially as a prompt enforcement of the order of July 14th might have thrown into darkness all that portion of the city lying between Thirty-fourth and Seventy-ninth Streets. Finally, the gas company actually began to experiment, but in a very original way. They engaged a man to make a soap with which to wash the smell out of the foul lime. A considerable quantity of it was used, and the members of the Board of Health and several other gentlemen were invited to witness the success of the operation. But the soap did not answer; it was tolerably effective on the upper layer of foul lime, but left the lower five or six layers as offensive as ever.

At last an iron mixture was procured; not one of those, however, which the messenger to Europe had seen in successful operation, and minutely described in his written report; nor yet the one in use by the New York Gas-Light Company, but a mixture which was once used somewhere in New Jersey and subsequently abandoned; a mixture of Spanish brown, shell-lime, and sawdust. Half the purifiers were filled with this mixture, while the other set were filled with lime as usual. They went through the motions of using this mixture in half the purifiers during most of the past summer, though the gas was actually purified, I think, by the purifiers containing lime. At all events, the mixture did not work, as might have been expected; and this autumn, as soon as the consumption of gas increased, the mixture was thrown out and the purifiers were again filled with lime. So this company has now gone back to the old process, and, in spite of all the evidence to the contrary, and all the time and money expended in bringing out that evidence, it still stubbornly denies the fact that foul lime creates a nuisance, or that any improvements have been made in gas purification.

The offensive process is now in full operation, and, more than that, the foul lime is actually used to fill in a pier. This is specially objectionable, as it has already happened in both London and Dublin that, in making excavations for sewers in places where foul lime had been used for filling in, the workmen were

killed by the gases evolved. Five men were killed at one time in this manner in London, in 1849.

Such is the history of the gas nuisance in New York, brought down to date.

V.—WHAT THE METROPOLITAN GAS COMPANY MIGHT DO.

This company has probably spent nearly $10,000 for expert fees, counsel fees, sending to Europe the man whose evidence was suppressed and whose advice was not followed, time of employés, printing two hundred pages of evidence, etc., all apparently with the design, not of suppressing the nuisance, but of defeating the honest efforts of the Board of Health in behalf of the citizens of New York. Suppose the officers of this company were really acting in good faith, with a sincere desire to obviate the nuisance, they could at once introduce a better process for purification, a cheaper process, by which they could save $10,000 per annum, or they could retain their present process and ventilate the foul lime. Let them follow the example of either of the neighboring companies, use the iron process of the New York Company, or the ventilating process of the Manhattan Company, or they may select any one of the improved iron processes now used in Europe. All that is asked of them is that they manifest the same willingness to direct their efforts to the management of their business in a manner most conducive to the health and comfort of the city, as was so promptly manifested by the other companies.

VI.—CHANGES REQUIRED.

The introduction of an iron process would require little if any change in the apparatus. Some iron mixtures are employed in exactly the same iron boxes with trays, as the company is now using for lime, while the greatest change that could be necessary would consist simply in taking out the movable trays and introducing a flooring of plank, perforated with augur-holes. A few hours would suffice to make the change; in fact, the plank flooring is already on the ground. A few days would be required to procure the necessary material. As there are two sets of purifiers, either of which could, in case of necessity, be made to purify all the gas made by the company, the change could easily be made without any serious interruption. Until within a short time, the New York Gas Company has been obliged to purify more gas than the Metropolitan Company now makes, with purifiers of no greater capacity than one of these two sets. To introduce the ventilating process, considerable additions would be required to the apparatus. A suitable engine, a blower, a washer, and a supplementary purifier for the air used in ventilating would be required, besides a considerable length of mains and the necessary connections. These additions would involve an outlay of several thousand dollars, and some months would be consumed in procuring and erecting them.

VII.—THE AMMONIA WORKS IN EIGHTEENTH STREET.

I cannot consider this report completed until I have referred to the peculiar odor which is evolved in West Eighteenth Street, and which is attributed by many to the Manhattan Gas Works. I refer to the odors which escape from

the Ammonia Works in that street. The ammoniacal liquor of the Manhattan Works is sold to parties who manufacture from it ammoniacal salts. This liquor contains sulphide, cyanide, and sulphocyanide of ammonium, carbonate of ammonia, and various other compounds which are offensive, but whose exact nature is not known. With careful management the treatment of this liquor need not cause offence, but it is so conducted at these works as to send forth a very disagreeable odor, which is mistaken by persons not familiar with the business for the odor of foul lime. I have noticed this odor, at some distance from the works, almost every time I have visited the neighborhood. The proprietors of the works should be induced to modify their process in such a way as to prevent this nuisance.

SPECIMENS.

In conclusion, I beg leave to submit a few specimens of the bog-iron ore and oxide-of-iron mixtures, which I collected in Europe this summer, and which are now in actual use in Liverpool, London, Paris, etc.

Respectfully yours,

C. F. CHANDLER, Ph. D.,
Chemist to the Metropolitan Board of Health.

NEW YORK, *December*, 1869.

THE PROCEEDINGS IN REGARD TO THE GAS NUISANCE.

Order No. 425.

OFFICE OF THE METROPOLITAN BOARD OF HEALTH,
No. 301 MOTT STREET, NEW YORK CITY.

At a meeting of the Metropolitan Board of Health, held on the 14th day of July, 1868, at said office:

The premises hereinafter named having been, and being in the opinion of said Board, and in fact, in a condition and in effect dangerous to life and health; and said Board having taken and filed among its records what it regards as being, and what is sufficient proof to authorize its declaration, that the same is a public nuisance, and dangerous to life and health; said Board does hereby enter the same on its records as a nuisance, and makes, in respect thereto, the following order, to wit:

Ordered, That the business of manufacturing (conducted by the Metropolitan Gas Company), at Foot of West Forty-second Street, be discontinued, except it be conducted by a process of manufacture that will not allow any deleterious gases or odors detrimental to health to escape into external air, and directs this order to be served as said law requires, and that, in case this order is not executed by the proper persons, the same be executed by the Board of Metropolitan Police; but that its execution be not commenced by the said Board of Metropolitan Police until the further order of this Board, of which further order no notice will be given to the parties interested.

As witness the signature of

EMMONS CLARK,
Secretary of Metropolitan Board of Health.

Suspension of Order and Notice of Hearing, under the First Clause of Section 14 of the Metropolitan Health Law, Chapter 74, of Laws of 1866.

Form No. 5. Order No. 11.

OFFICE OF THE METROPOLITAN BOARD OF HEALTH,
No. 301 MOTT STREET, NEW YORK, *July* 29, 1868.

This Board having, on the 14th day July, 1868, made an Order (being Order No. 425) relative to the business of manufacturing gas at the foot of West Forty-second Street, New

York, and having declared the same to be a public nuisance, and to the general effect that the business of manufacturing gas (conducted by the Metropolitan Gas Company) at foot of West Forty-second Street, New York, be discontinued, except it be conducted by a process of manufacture that will not allow any deleterious gases or odors detrimental to health to escape into the external air; and the same having, on or about the 15th day of July, 1868, been served upon Oscar Zollikoffer, President of the Metropolitan Gas Company, being the proper party, and said Oscar Zollikoffer having requested the opportunity to be heard before this Board, which said clause of said section authorizes, the execution of said order is hereby suspended until the further order of this Board.

And notice is hereby given to the said Oscar Zollikoffer, who has requested an opportunity for a hearing, that he will be heard, and can present facts and proofs, as said law and the regulations of this Board provide, before this Board, at its office as above, on the 1st day of August, 1868, at 10 o'clock A. M. on that day, or as soon thereafter as said hearing can be had. Said applicant must take notice of the adjournments of this Board, and of its rules and regulations, and of its final Order in this matter, and must be prepared to proceed in said matter, at said time and place, and at any subsequent meeting, as the business of said Board will allow; and all without further notice, beyond the service of a copy hereof.

As witness the signature of EMMONS CLARK,
Secretary of said Board of Health.

HEARING BEFORE THE REFEREE.

At a hearing before the undersigned, D. B. Hasbrouck, held at the office of the Metropolitan Board of Health, No. 301 Mott Street, New York, on the 1st day of August, 1868, in pursuance of the order and notice of the Metropolitan Board of Health, a copy of which is hereto annexed:

By consent of both parties the hearing was adjourned to August 5, 1868, at 10 o'clock A. M. No testimony was offered.

At the adjourned hearing, August 5, 1868, at same place, by consent of both parties a further adjournment was had to August 10, 1868, at 11 o'clock A. M. No testimony was offered.

At the adjourned hearing before the undersigned, D. B. Hasbrouck, held at the same place on the 10th of August, 1868, *Oscar Zollikoffer*, President Metropolitan Gas Company, appeared in person, and by *Hon. H. C. Van Vorst, Counsel; the Metropolitan Board of Health, by Col. George Bliss, Attorney, and by H. C. Allen, Assist. Attorney.*

TESTIMONY OF SAMUEL P. PARHAM, ASSISTANT-ENGINEER OF THE METROPOLITAN GAS-LIGHT CO.

SAMUEL P. PARHAM called for the Metropolitan Gas Company, being duly sworn, testifies as follows:

By Mr. Van Vorst: Q. Where do you reside? A. 354 West Forty-eighth Street.

Q. What is your business? A. Gas engineer, of a practice of twenty-six years, and all branches connected therewith.

Q. How long have you been connected with the Metropolitan Gas Company? A. Eight years, or nearly so, within a few months.

Q. In what capacity? A. As assistant engineer in constructing works, and afterward assistant engineer for the works of the Company.

Q. What are your duties as assistant engineer of the Company's works? A. My special duties in charge of the distribution outside the works, to assist the engineer when called upon inside to make any drawing, alteration, or extension.

Q. With what Company were you connected before you connected yourself with the Metropolitan Gas Company? A. Twenty years ago I was Superintendent of the Trenton Gaslight Company; afterward I was engineer, repairing works in different parts of the United States, and then in business until eight years ago, in business for myself.

Q. Connected with the Philadelphia Gas-Works? A. No, sir.

Q. With what other gas works have you been connected besides the Metropolitan and the Trenton? A. The York, Pennsylvania, Gas Works; consulting engineer at Pottsville, consulting engineer at Fredericksburg, Maryland, and at Columbia, South Carolina.

Q. Macon? A. No, sir. I was builder of the Trenton Water Works. That is outside the question, though.

Q. What had you to do with the process of manufacture of gas for the defendants? A. I had more particularly the distribution, and to take the engineer's place when absent; at the same time I overlooked every thing round the works for the company's interest.

Q. What coal does the Metropolitan Gas Company use for the manufacture of gas? A. They use different veins of coal, but all of the best quality. They use the best coals in the city of New York or in the United States; no better coals can be procured—Boghead, Cannel coal, Armiston coal, Lutheon, St. Hellen, Inchal, Lesmahago.

Q. Is this company particular about getting the best quality of coal, and that freest from injurious ingredients, out of which to make their gas? A. There is no company in the United States has better coal than the Metropolitan; it buys the best that can be purchased in the market; the Scotch cannel ranks the highest in the world, and we have it, and the bituminous holds the same rank.

Q. You import a good deal of coal? A. Yes, sir.

Q. Where are the company's works located? A. Forty-second Street and North River.

Q. The gas is manufactured there? A. Yes, sir.

Q. It is west of Eleventh Avenue? A. Yes, sir.

Q. Can you state how the gas of the Metropolitan Company is purified? A. Purified by what is called the dry-lime process.

Q. Now you may explain it.

A. It is the oyster-shell lime which is the best, because it is more like a powder; it is moistened, damped a little, and put into trays.

Q. You call them trays? A. Trays; we put them on purifying boards, sieves.

Q. This lime is put in these purifying boxes? A. Yes, sir.

Q. Describe the process. A. There are four purifiers, and the gas passes through three of these boxes at one time, and passes through the lime contained in these boxes; we test the quality of gas from time to time; there is no set time to change these boxes, but it is decided with a test paper; when it is shown that the gas is the slightest foul, then a new purifier is put on, and the old one is cleaned.

Q. How many boxes do you use? A. Four.

Q. Don't you use more than that? A. We have eight, that is two sets, four is a set.

Q. At certain seasons of the year you use them all? A. Yes, sir; in the winter.

Q. Now will you state, if you please, what office the lime performs in purifying the gas; what it disengages from the gas? A. It extracts the sulphuretted hydrogen gas, carbonic acid gas, whatever ammonia the water does not take out by the washers.

Q. Does the lime take out the ammonia? A. Whatever portion comes through retains a good deal of it; we depend more upon the washers for the ammonia and the condensers.

Q. It takes out those matters? A. From the gas; these are foreign matters we do not want; we want the illuminating matters.

Q. Do you know what becomes of them? A. Are detained in the lime.

Q. They enter into combination with the lime? A. Yes, sir.

Q. What does the lime become? A. It becomes foul, as we say.

Q. You say it enters into combination with the lime? A. In the washers it goes with the water and tar. The sulphuretted hydrogen and carbonic acid comes here combined with the lime; these are the principal gases which are contained.

Q. You say they are taken up upon the lime? A. Yes, sir; and contained by the lime.

Q. Do any of them go into the air, and if so, what? A. When the lime is exposed, I presume it does—when the foul lime is exposed.

Q. What goes into the air? A. The emanations from the lime—whatever has an affinity for the air, and the air has an affinity to pass off.

Q. What becomes of the lime? A. The lime is thrown into the yard, and then sold as a fertilizer.

Q. State when, and how often, the boxes are emptied? A. We have no set time for the boxes.

Q. I mean for this lime? A. Will say they run twenty-four hours during the winter, and during the summer, when our make is not very great, run two or three days before the boxes are changed.

Q. The lime is emptied? A. The lime is emptied—some coal contains more sulphur than others—the whole thing is a chemical counterbalance.

Q. Your effort is to get that coal which has the least sulphur? A. Yes, sir; it is the cheapest and best for the consumer.

Q. What becomes of the lime? A. The lime is taken out of the boxes and wheeled to the yard, and there it remains, or there it is conveyed upon vessels and carried to the country as a fertilizer.

Q. What agent is used in the purification of gas in the other works with which you have been connected? A. Lime; dry lime; I never used any other than dry lime.

Q. Have you had any experience in the use of any other agent except dry lime? A. No, sir; I have tried experiments with iron filings and potash, but they were mere experiments.

Q. When did you perform these experiments? A. It was twenty years ago, in Trenton, New Jersey, in 1848.

Q. How did they succeed? A. They made gas very brilliant, sir, but very expensive. It was mere laboratory experiments. Potash, iron filings, and sulphur. The sulphur need not have been there.

Q. Brilliant gas, but very expensive? A. The process was very expensive. It was too expensive for general use.

Q. Have you been at the New York Gas Works? A. Yes, sir.

Q. Lately? A. Last Wednesday, sir, I was there looking at the process of purifying. I was accompanied by Mr. St. John, one of the patentees. He explained to me all, I presume. I do not know that he kept any thing back.

Q. What agent do they use there for purification? A. Oxide of iron; iron filings I saw there and charcoal, and I think he damped it with ammoniacal liquor. If there was any thing else, he did not tell me of it.

Q. You were there with the engineer? A. With the patentee, Mr. St. John.

Q. Is their process of purification of gas patented? A. Yes, sir; it is in the composition. It is not in the method of purifying; some compounds they have got there.

Q. Have you ever witnessed any experiments for the purification of gas by that method except this one of the New York Company? A. No, sir; I have not. But I have read a good deal of all kinds of processes, in purifying gas. A good many patents have been taken out for oxides—oxide of iron, oxide of zinc, oxide of manganese.

Q. Do you know what agent is used in the United States, in the large cities of the United States, for the purification of gas? A. Generally dry-lime process; Philadelphia uses it altogether, nothing else.

Q. Do you know by whom the Philadelphia Gas Works are owned? A. By the city of Philadelphia.

Q. The Municipal Corporation of Philadelphia manufactures its own gas for the citizens? A. Yes, sir.

Q. And in the process of the purification of the gas it uses dry lime? A. Dry lime—yes, sir.

Q. Do you know how it is in the city of Boston? A. No, sir, not particularly; I have not heard any thing to the contrary of dry lime.

Q. Do you know of any cities or any gas works where iron or the oxides of iron, or iron filings, or that process is resorted to for purification, except the New York Gas Works? A. None that I know of or ever heard of.

Q. Which do you consider the best method of purification of gas, as far as your knowledge and experience are concerned? A. Dry-lime process.

Q. Do you know of any evils attendant upon it, or any consequences injurious to health attendant upon that process of purification of gas which would not be attendant upon any other process? A. I do not know that this is unhealthy; my family reside out of the city

of New York, and I sleep off and on with a one-foot brick wall between me and the purifying-room, and I never was sick or experienced a headache, not the slightest indisposition; in short, if there were an epidemic, I would remove my family to the works. In '66, when the cholera was here, I slept that season in the works, and never experienced the slightest indisposition; if there were an epidemic, I would get my family as near the works as I could—either the yellow fever or cholera. There was but one person in Portsmouth, Va., that was taken with cholera, and he was taken from the works, and was brought back, and recovered. I have it from our engineer, who was in the neighborhood.

Q. Do you know of any thing unhealthy about the Metropolitan Gas Works? A. I do not; all our men are perfectly healthy; I do not know of a case of sickness; no later than Friday or Saturday there were two nurses, with four children, sent there by the physicians, with the whooping-cough; they were in the purification-room inhaling the gas.

Q. Is it a usual occurrence for children to be sent there? A. Yes, sir; I have known a great many.

Q. To inhale the gas as a medical agent? A. Yes, sir; I have seen gentlemen bring their children there in carriages; so it is not the lower class that comes there, but the higher class.

Q. What do you know about the health of the neighborhood of your gas works? A. It is very healthy, sir; uncommonly, sir, round our immediate neighborhood.

Q. Do you know any thing about any epidemics prevailing there, among children or adults? A. No, sir; there is a place opposite, where there are a great many families; I do not know how many; I think there is but one death in a year; it is very seldom you see a funeral.

Q. Are there many children about your streets? A. Yes, sir.

Q. It is a prolific neighborhood? A. Yes, sir, quite so.

Q. You stated you observed the process of purification at the New York Gas Works? A. Yes, sir.

Q. Will you state what you observed in regard to it, and what, if any, advantages or disadvantages there were attendant upon it, according to your observation and experience? A. I could not see any.

Q. What? A. Any disadvantages; but I think there must be a good deal in the gas, because I do not think it takes out all the *carbonic acid gas and sulphuretted hydrogen;* I do not think the iron takes all the carbonic acid gas; we want lime to detain carbonic acid gas; they were not using a particle of lime, and in many places where they do use the oxide of iron they must use lime; you cannot get along without lime, that is, if you want pure gas.

Q. You cannot get along without lime in the purification of gas and have a pure gas? A. I do not believe you can have a pure gas.

Q. The gas, you think, manufactured by the New York Gas Company is not as pure as the gas manufactured in your works? A. I do not think it is as pure, and I do not think its illuminating power is as strong; that is eye observation, from looking at it, sir.

Q. What effect has it upon the health where gas of that character is burned, where those injurious elements of which you speak are not taken from it? A. I should think injurious to health; if it was not injurious to health there would be no necessity for us to take it out, for it costs us something to do it.

Q. You take it out as a matter of healthfulness, this portion of the gas? A. Yes, sir.

Q. And the lime process really does extract them, and if they were not taken out they would be evolved in the process of cumbustion? A. Yes, sir; if we did not take it out there, the consumer would get it.

Q. Did you explain what became of the lime after the boxes were emptied? A. It was taken out, thrown into barrels and taken into the yard, and from there we ship it in canal-boats, and it is conveyed to different parts of the country as a fertilizer.

Q. And it is a good fertilizer? A. Yes, sir; we use it ourselves for filling—mixing it with "breeze" or coke-dust. Permit me to read a little paragraph. It is by Lewis Thompson, one of the best gas authorities in England. (Witness read from "The Chemistry of Gas-Lighting," London, as follows): at page 31, he says:

"Every one knows that the purifying agent first employed by Windsor was lime; and recent experiments, conducted with the most scrupulous care and by the most experienced manipulators, have shown, beyond all doubt or question, that nothing whatever is so well adapted for the complete purification of gas from its most pernicious impurities; and nothing tends so much to preserve its illuminating power, as the very article used and selected before all others by Windsor—that is to say, common lime. It would hence appear that our progress in the art of purifying gas has been *nil;* for, although almost every chemical agent of a moderately cheap kind has found itself enlisted into the service by one patentee or another, yet, in the present day, those best acquainted with the purification of gas in a particular way, tell us unanimously that lime alone is the only substance which will effectually remove the chief impurities of coal-gas, without so serious a destruction of illuminating power as to require the introduction of a new element in the calculation of the cost. That is to say, the employment of a portion of cannel coal by way of compensating for the loss which every other purifying agent but lime causes in the illuminating power of gas.

"That common lime used in a dry-lime purifier is the most effectual, economical, and least hurtful agent to which impure gas can be subjected, no practical man can venture to deny; and next to this may be classed lime used in a wet purifier, though this is much less effective, and very apt to leave carbonic acid in the gas. Of course this purification goes no further than to the acidulous compounds contained in the gas, such as carbonic acid and sulphuretted hydrogen. But something may be learned, nevertheless, from this peculiar fitness of lime, even in respect to the removal of the alkaline compounds. It would appear that neither carbonate of lime nor the hydrosulphate of lime possesses any affinity for those naphthas, or hydrocarbons, upon which the luminosity of gas depends. Hence the lime, when fully saturated, or, as the phrase is, when 'foul,' contains nothing of the light-giving principles of gas, for these have passed on untouched. A very different result, however, takes place with the oxides, carbonates, and sulphates of the metals proper."

Q. What do you say about him as an authority? A. He is a gas authority.

Q. How eminent an authority? A. One of the most eminent men. Dr. Letheby, I think, is ahead of him.

Q. What other author have you? A. Rev. Mr. Bowditch's Analysis—page 21—he speaks of all the processes from the beginning.

Q. Which process does he favor? A. He seems to favor his own.

Q. What is that? A. Hot lime and clay purification. I do not know of anybody using that at all.

Q. What does he say about the lime process—dry lime? A. Page 21, speaking of the oxide of iron, he says: "Although this process of purification is a great point to large gas companies, it has its drawback to consumers. Because when it comes into use much carbonic acid is left in the gas; and secondly, because, when the foul oxide is spread out to revivify, it casts off a quantity of very offensive compounds, which seriously annoy those who reside in the neighborhood of the works; where the foul oxide is exposed to revivify in the free air, the evolution of sickening vapors emitted by foul oxide may be carried through chimneys, and through fires, into the atmosphere so as to be rendered harmless."

I have the report of the annual meeting of the British Association of Gas Managers; they have a number of processes introduced; there is one I should like to say something about; it is the fifth annual general meeting of the General Association of Gas Managers, held in London, June 2d, 3d, and 4th, 1868; I read from the *Journal of Gas-Lighting*, page 474, from the President's Inaugural Address: "In the process of purification, but little advance has been made. Experience, however, serves to confirm Dr. Letheby, that the sulphur compounds in gas may be considerably reduced by dry purifiers of large surface, through which the gas passes slowly. This has been shown to be the case at the Great Central Gas Works, where the quarterly average of sulphur has by that means been reduced from 30 grains to less than 20 grains per hundred cubic feet." In speaking of the different tests: "Mr. Ellison, the chief of the Experimental Works of the Paris Gas Company, observes that any portion of sulphur in gas that can be injurious to health or to property, is that portion which is eliminated in the form of sulphurous acid during ordinary combinations, and that in a labora-

tory test, by means not commonly adopted, can extract a larger quantity of gas, is, or ought to be, useless as a test of the purity of the gas to the public." There are a great many others, if you wish to have them; I have these papers for a number of years.

Q. The dry-lime process has the effect to remove the sulphur from the gas? A. Yes, sir; sulphuretted hydrogen and carbonic acid.

Q. And is lime the best known agent that you know of to remove it? A. Yes, sir.

Q. If not removed it remains with the gas, and is evolved with its combustion? A. Yes, sir; it goes out somewhere.

Q. And makes the gas impure and injurious to health? A. Yes, sir; in 1866 the Great Central Gas Company begged to be permitted to use wet-lime purifiers; that is, in the second rank of purifiers; Mr. Thompson states, the first is dry lime, and the second is the wet-lime process; and the third the oxide of metals—of zinc, iron, or other metals.

At the thirty-first half-yearly ordinary meeting of the shareholders of the Great Central Gas Consumers' Company, held in London, October 26, 1866, the chairman said (witness read as follows): "The sulphur question is one of our great difficulties. We have grappled with it in the most effectual manner we can. We have done every thing in our power to reduce the quantity in the gas; we have gone to a large expense in picking out the pyrites from the coal, and we have employed a most eminent chemist, Professor Redwood, in addition to our ordinary staff, to assist us in our endeavors to get rid of the cause of complaint. We also invited Dr. Letheby, though without success, to visit our works, and favor us with any suggestions in his power upon the subject. It is one of those obscure things which we cannot fathom. Sometimes we are below 20 grains; occasionally we are above that standard. Of course, in purchasing coal our great object is to obtain that which contains the least sulphur, but it will occasionally happen that coal, in the same pit as the vein is worked out, is found to have a larger quantity of sulphur in it at one time than at another. We should have no difficulty whatever if we could use the wet-lime process of purification. Some companies are so situated that they can do so, but if we were to attempt to do it at Bow Common, as we used to do, we should fall again into trouble with the local authorities. We have been brought up before the police magistrate for nuisance." "The use of wet lime is, therefore, prohibited to us. We are about to try some modification of the lime process, using lime in some form, and to a certain degree, to enable us to come within the standard prescribed by Parliament, which I hope may be successful."—(*The Journal of Gas-Lighting, etc., Oct.* 30, 1866, p. 790.)

Cross-examination by Mr. Allen: Q. To come back to the gas works of the Metropolitan Gas-Light Company; how long does this refuse lime remain on the premises, ordinarily, after it comes from the purifiers? A. A month or two—week; probably we take some in less than a week.

Q. Is it deposited in the yard in heaps? A. Yes, sir; there is a heap of it in the yard now.

Q. What is the condition of this refuse lime, as to its temperature, when it comes out of the purifiers? A. It is warm.

Q. I mean at the time it is in the purifiers—is it hot or cold? A. Cold in the purifiers.

Q. On being exposed to the air, does it become hot? A. Yes, sir; it gets hot then; it is the uniting of the air that makes it warm.

Q. Are there any odors escaping from this heap after it is exposed to the air? A. The greatest odors are in the removing from the purifier and taking it out.

Q. Answer my question, please; are there, or are there not, odors that escape into the air from this refuse lime after it is removed from the purifier? A. Yes, sir; a little.

Q. Do you know of what that odor consists—of what gases? A. Odor of sulphuretted hydrogen and ammoniacal odor.

Q. It is then the odors of the gases that are absorbed in the purification? A. Yes, sir;

Q. Do they undergo any chemical change by uniting with the oxygen of the air? A. I presume they do.

Q. Do you know what? A. No, sir; I cannot say that I do. It throws off sulphuretted hydrogen and carbonic-acid gas into the air; and the lime after a while has no smell. The pile there don't smell at all.

Q. You stated in your direct examination that the carbonic-acid gas was taken out from the gas in these purifiers for the purpose of health? A. Yes, sir.

Q. Does carbonic-acid gas in the gas diminish its illuminating power? A. It does.

Q. But you extract it because it is detrimental to health? A. It would be impure gas.

Q. To what extent would the amount of carbonic-acid gas lessen the illuminating power? A. I presume it would lose a candle-power or so. Some make it a great deal more than that: and at the same time it would be impure gas.

Q. What is the amount of carbonic-acid gas, in a thousand feet of gas, before it is purified? A. I never measured: we have no laboratory to measure it.

Q. Is there any perceptible difference in the amount of this odor which comes from the amount of refuse lime in the different degrees of temperature or humidity of the air? A. It is about the same to us at the works.

Q. The amount of odor is the same in wet weather and in dry? A. To us at the works; I cannot answer any thing beyond the works.

Q. Have you ever visited the Philadelphia Gas-Works? A. Yes, sir; many times.

Q. Did you perceive this same odor from this mass of lime in those works? A. Precisely the same—yes, sir.

Q. What knowledge have you of the health of the neighborhood in the vicinity of the Metropolitan Gas-Works? A. It is said to be good.

Q. Have you any personal knowledge? A. I am there every day.

Q. Have you any personal knowledge? A. No, sir.

Q. You infer that the gas-works are healthy, from the fact that physicians have sent children there? A. I only judge from myself.

Q. You mentioned the fact? A. Yes, sir; physicians sent children there; I was myself eighteen months inside the works; I have slept inside the works, and never sick the slightest.

Q. Have you never heard of physicians giving strychnine to sick people? A. No, sir.

Q. Or calomel? Yes, sir; I have taken it myself.

Q. Would you recommend that the whole community should be given a dose of calomel or strychnine? A. Might, if it would do them good.

Q. You are not an expert in medicine? A. No, sir.

Q. You have no knowledge of the effect of this gas upon the public health? A. No, sir.

Q. Will you state what, in the process of the New York Gas-Works, is patented? A. No, sir; I never examined their claim; it is in the composition; they may use some little thing that others do not; some patents contain saw-dust; they do not use saw-dust.

Q. Have you any knowledge of the illuminating power produced by the New York Gas-Company? A. No, sir; I have heard it was 13 or 14 candles; I never examined it photometrically.

Q. Will you take that book—"The Chemistry of Gas-Lighting"—and at page 32, and read the last clause at the bottom of the page, commencing, "superior in activity"? (Witness read as follows:) A. "Superior in activity to the sulphate of lime, the muriate of that base next claims attention, and the mode of using this substance patented by Mr. Laming, seems to possess the greatest amount of advantages; but whatever the plan, the theory and practice of the application of these lime-salts are equally satisfactory; the ammonia combined with carbonic acid is arrested by the lime-salts employed, and a double decomposition, attended with the production of two new substances, neither of which have any affinity for the illuminating matters of the gas."

Q. Turn to page 36—"Chemistry of Gas-Lighting"—and read the first paragraph of the page, beginning, "And there is." (Witness read as follows:) A. "And there is this very great advantage in favor of the aforesaid arrangement of muriate of lime, oxide of iron, and hydrate of lime, that it entirely obviates all smell and nuisance from the Gas-Works."

Q. Now, from the next paragraph, commencing at "Foul lime." (Witness read as follows:) A. "Foul lime, as it is removed from the purifier, consists of an admixture of several salts, some of which, as the ferrocyanate, sulphocyanate, and hydrocyanate of lime, are in such minute quantities as to require no notice here; but there are others, such as the

carbonate and the hydrosulphate of lime, and the hydrosulphate of ammonia, which are in considerable quantity and constitute an important part of the total bulk. There is also a quantity of hydrate of lime in an uncombined state, and which may be said to be wasted. The analysis of these principal compounds shows that the salts exist in about the proportion which our estimate of the impurities in coal-gas would indicate—that is to say, more than half the mass consists of carbonate of lime, nearly one-fourth of hydrosulphate of lime, about one-fifth is hydrate of lime unacted on, and the residue contains the cyanogen, salts, and the silicious, and other impurities of the limestone, with a variable proportion of hydrosulphate of ammonia, retained in the mass mechanically. With such a mixture, it is not surprising that an offensive odor is emitted on exposure to atmospheric air, for, in the first place, the hydrosulphate of ammonia must pass into the air by a simple process of diffusion, while the hydrosulphate of lime, being acted upon by the carbonic acid of the atmosphere, will give rise to the formation of carbonate of lime, and a copious evolution of sulphuretted hydrogen gas. And it is in this latter particular that the use of oxide of iron has its greatest recommendation; for, as we have before stated, the affinity of oxide of iron for sulphuretted hydrogen is greater than for carbonic acid, whereas with lime the contrary is true. Hence the sulphuret of iron, not being decomposed by the carbonic acid of the air, emits no odor, while the sulphuret of lime is readily decomposed, and thus produces an abominable nuisance."

Q. Now please read from page 37, the fourth paragraph, commencing, "But where." (Witness read as follows:) A. "But where the necessity for avoiding nuisance is consider able, the spent lime should contain as little ammonia as possible, for the sulphuret of calcium alone decomposes very slowly by contact with atmospheric air, and has rather a tendency to absorb oxygen and generate hyposulphite of lime than to evolve sulphuretted hydrogen by combining with carbonic acid. When ammonia, however, is present, this rapidly absorbs carbonic acid; and the carbonate of ammonia, thus produced, instantly reacts upon the moist sulphuret of calcium, whence result carbonate of lime and hydrosulphate of ammonia—the latter of which, by evolving its characteristic odor, gives rise to the well-known offensive stench of gas-lime refuse."

Q. Read from page 41, the last clause of the middle paragraph. (Witness read as follows:) A. "Hence the oxides of manganese, iron, zinc, lead, copper, and antimony, have been laid under the 'taboo' of the patent law by various inventors, though at present the oxides of iron, lead, and antimony, are the only ones in practical use in this country."

Q. Page 51, the last paragraph. (Witness read as follows:) A. "In the April number of the *Journal of Gas-Lighting*, for 1850, a communication will be found from a correspondent of the *Mining Journal*, which illustrates the above position. Having prepared a mixture of lime and sulphate of iron, so as to produce hydrated sesquioxide of iron, this was placed in a dry-lime purifier, and the first trial was found to have purified only 1,500 cubic feet of gas; after exposure to the air it purified 2,400 cubic feet; on a second exposure to the air, it purified 3,050 cubic feet, and ultimately, upon another exposure, it reached as high as 4,200 cubic feet, or very nearly three times the original quantity; and this result accords exactly with the daily experience of gas engineers upon the subject."

Q. In the work of Mr. Lewis Thompson, in the paragraph you read on the 31st page, as I understand the drift of this work, it is to determine which is the most economical method of manufacturing gas? A. The least hurtful; on the same page it says that dry lime is the most effectual, economical, and least hurtful agent to which impure gas can be subjected.

Q. I want to get at what he means by "hurtful;" hurtful to the public or hurtful to the gas? A. Hurtful to the gas, I presume.

Q. Is this work ("Chemistry of Gas-Lighting") a sanitary work, or a practical work for the gas-manufacturers? A. It was written for the science of gas—for the gas engineer.

Q. Has no bearing whatever upon the results of gas-making in a sanitary point of view? A. I think not; it is to render impure gas pure gas; the object is to deliver as pure a gas to the consumer as possible; if it is an impure gas, it is unhealthy, I presume.

Q. I understood you never had had any experience yourself in the oxide-of-iron process?

A. No further than the little experiments I spoke of; but not in a general way; for it is not used in this country.

Re-direct examination by Mr. Van Voorst: Q. How soon do the odors from the lime-heap escape after being removed from the boxes? A. Almost as soon as the lids are removed.

Q. How soon does it terminate? A. Within three or four hours.

Q. Does that heap of lime emit any odors? A. No sir; not that I know of, sir.

Q. The heap of lime itself, after it is removed for two or three hours, emits no odors? A. No, sir; the spent lime emits no odors.

Q. Your attention has been called as to whether you have any experience as to the health of the community; I ask you, what portion of your time have you spent in these particular gas-works for six or eight years past? A. I am there probably half my time.

Q. In the works? A. I am there four times a day, sir; probably an hour each time.

Q. Have you any knowledge of any disease prevailing in that neighborhood among children or adults, more than any other part of the city? A. No, sir; I have not heard of any.

Q. Or whether that neighborhood is a healthy or unhealthy neighborhood? A. Never heard of its being unhealthy.

Q. Ever heard of any complaints from people in the neighborhood of it? A. No, sir; I have heard them complain of smells, but smells of fat-houses.

Q. Are there fat-houses round there? A. Yes, sir; there is a steamship that boils animals I have seen piled up on the pier; I think Thirty-eighth Street; it is terrible; sometimes made me sick.

Q. Where is that? A. That is on the North River, just below me.

Q. Describe what kind of an establishment that is. A. I have never seen it, only from our works; I have seen animals go there.

Q. Dead animals that are carried there? A. Yes, sir.

Q. Boiled up? A. Yes, sir; or cut up in some way.

Q. Did you detect the odor from those works? A. Yes, sir.

Q. I want to know what it is. A. There is dead animals boiled there.

Q. Animals which have died a natural way are sent there and boiled? A. Yes, sir; I have smelt it for eight years.

By Mr. Allen: Q. Those are odors of decomposed animal matter? A. Yes, sir.

By Mr. Van Vorst: Q. Very disagreeable and very offensive? A. Yes, sir.

Q. Do you know of any other causes of the production of disagreeable and offensive odors in that neighborhood? A. No, sir; there is a sewer.

Q. How long has that establishment for boiling of those dead animals been there? A. It is eight years since I went there, and I have smelt it there every year.

Q. Is it existing there? A. Yes, sir.

By Mr. Allen: Q. Has it ever made you sick? A. Yes, sir.

By Mr. Van Vorst: Q. Do you know of any useful purpose it is accomplishing? A. No, sir.

By Mr. Hasbrouck: Q. About how much lime is used? A. The charge to a purifier would be about 250 bushels.

Q. Is it not practicable to immediately convey this lime, when it is taken out of the purifier, away to some place where it will be inoffensive? A. I think in a few hours after there is no smell.

By Mr. Van Vorst: Q. How often do you open the boxes? A. Every two or three days; it is according to the gas passed through; in the winter time, when passing a large amount of gas, every day.

Q. Do you know any thing about the arrangement made by the company for the removal of the lime? A. No, sir; the president has that arrangement.

Q. It is not allowed to remain there any longer than necessary? A. No, sir.

TESTIMONY OF PROF. C. F. CHANDLER, CHEMIST, TO THE BOARD OF HEALTH.

By Mr. Allen: Q. What is your profession? A. Chemist.

Q. Are you connected with any public institution in this city? A. Yes, sir; I hold the chair of Analytical and Applied Chemistry in the School of Mines of Columbia College?

Q. And also Chemist of the Metropolitan Board of Health? A. Yes, sir

Q. Have you paid special attention to the chemistry of illuminating gas? A. Yes, sir.

Q. From what is illuminating gas prepared? A. Bituminous coal.

Q. What is the composition of bituminous coal? A. Carbon and hydrogen, with some sulphur and nitrogen, and earthly and silicious impurities which constitute the ash.

Q. How is the gas prepared from the coal? A. By exposing it to a high temperature in retorts of iron or clay.

Q. What are the products of this? A. Coke, tar, ammoniacal liquor, and gas.

Q. What becomes of these products? A. The coke remains in the retort; the tar and ammoniacal liquor accumulate in the hydraulic main, and in the condenser and scrubber; the gas passes on to the purifiers.

Q. What is the composition of the gas as it leaves the hydraulic main you speak of? A. It consists chiefly of marsh gas, carbonic oxide, and hydrogen, which are the non-illuminating combustible constituents; of olefiant gas, and several other hydro-carbon gases and vapors which are the illuminating constituents—sulphuretted hydrogen, carbonic acid, ammonia, cyanogen, sulpho-cyanogen, nitrogen (I believe those are the most important ones), bisulphide of carbon, aqueous vapors; this last group of eight constituents constitute the useless or injurious impurities; I did not mention the hydro-carbons individually; there are a dozen or twenty which I group.

Q. Have you ever visited the works of the Metropolitan Gas Company? A. Yes.

Q. What process do they use there for purifying the gas? A. The dry-lime process.

Q. What is the composition of the lime after it has acted upon the gas? A. It consists essentially of sulphide of calcium, carbonate of lime, hydrate of lime, and contains small quantities of ammonia, cyanide of calcium, sulpho-cyanide of calcium.

Q. Is that all? A. Except a little tarry matter; maybe minute traces of other things, but those are the essential constituents.

Q. What occurs when this spent or useless lime is exposed to the air? A. The ammonia absorbs carbonic acid, forming carbonate of ammonia; the carbonate of ammonia decomposes the sulphide of calcium, forming the sulphide of ammonium, which is evolved; carbonic acid decomposes sulphide of calcium, liberating sulphuretted hydrogen; oxygen is absorbed with the evolution of heat, and the formation of hyposulphite, sulphite, and sulphate of lime. These are the more important reactions.

Q. What is the nature of this gas as to its offensiveness, when evolved in the air? A. The sulphuretted hydrogen and sulphide of ammonium are the predominant constituents of the disagreeable odors evolved by the lime refuse.

Q. The fact is they produce a disagreeable odor? A. They have a disagreeable odor.

Q. Is this disagreeable odor equally perceptible in all kinds of weather? A. No; in dry, clear weather, the odors rise rapidly in the air, but in damp, heavy weather, particularly with the wind favorable, the odor will diffuse itself throughout the neighborhood.

Q. Would this lime be equally offensive, if more lime were used for the same quantity of gas? A. It would make a little difference, perhaps, but the odor is not due to over-saturation; in fact, the refuse contains fifteen or twenty per cent. of unchanged hydrate of lime; consequently it is never over-saturated.

Q. Is it possible to prevent the escape of foul odors from the dry-lime process? A. I think not.

Q. We come to another point: Is it necessary to employ the dry-lime process for the purification of gas? A. I think not; I know it is not.

Q. What is the wet-lime process? A. That is a process in which the lime is mixed with a large quantity of water, to the consistency of cream, and the gas obliged to bubble through it; the chemical reactions are the same as in the dry-lime process.

Q. Is that in general use? A. No; I have seen it in use in some places, but I believe it is generally abandoned; it is sometimes used with the iron process, for the more complete removal of carbonic acid, after the sulphur has been removed by oxide of iron.

Q. What is Laming's process? A. It consists in using a mixture of the hydrated sesquioxide of iron, sulphate of lime, hydrate of lime, and sawdust, or some other porous material;

the mixture consists of dry-slacked lime and sawdust in equal quantities, to which is added, for every pound of lime, one pound of sulphate of iron (copperas), dissolved in water. The mixture is exposed to the air for twenty-four hours, to oxidize the protoxide of iron to the sesquioxide. It then consists of hydrated sesquioxide of iron, sulphate of iron, hydrate of lime, sawdust. In the place of copperas, double the weight of sesquichloride of iron is sometimes used, when the mixture consists of hydrated sesquioxide of iron, chloride of calcium, hydrate of lime, sawdust.

Q. What are the disadvantages of Laming's process? A. It is said to be somewhat more expensive in some cities than the dry-lime process, while in other places it is said to be much cheaper.

Q. Has it any advantages? A. It has been claimed by some that the gas suffers slightly in illuminating power, though even if this be true, it could easily be remedied by the use of a larger proportion of cannel coal, or the use of small quantities of Albert or Boghead coal; it is stated, however, by others, that no such loss in illuminating power occurs; Unruh, in Magdeburg, where the process is employed, found that the illuminating power was not at all diminished, while the sulphuretted hydrogen was entirely, and the carbonic acid almost entirely removed, the process being much cheaper than dry lime; it has also been stated that it fails to remove the carbonic acid completely, but, should this difficulty occur, it can be easily remedied by the use of a little lime after the iron mixture; those are the answers to the disadvantages.

Q. Has it any advantages? A. The gas passes more readily through the mass; the mixture may be used over and over again, and when it finally becomes useless for purifying gas, may be sold for the extraction of the sulphur it contains; but the most important advantage consists in the entire suppression of the disagreeable smell which is evolved from the dry-lime refuse.

Q. Will you describe the iron-ore process? A. In the iron-ore process, brown hematite, or bog-iron ore, in coarse powder, is employed to absorb the sulphuretted hydrogen; this substance is an impure hydrated sesquioxide of iron, and has the same action on the sulphuretted hydrogen of the gas as has already been mentioned in describing Laming's process; I am informed that at the new gas-works in Berlin a bog-ore from Silesia is employed; it is dried, pulverized, sifted, and placed in the purifier either alone or mixed with sawdust; it is cheaper than Laming's mixture; it is regenerated slower at first, but more rapidly afterward, and its action on the gas increases with use; at Hanover, the iron-ore of Lunenberg mixed with spent tan-bark is employed.

Q. Is this process in use in this country? A. With slight modifications it is employed at the New York Gas Company's works, on East Twenty-first Street.

Q. What are the modifications employed at the New York Gas-Works? A. Iron-ore from Staten Island is mixed with sufficient quantity of iron turnings, filings, or borings, to increase the amount of iron to eighty per cent.; the mixture is moistened with ammonia-water and exposed to the air, when the metallic iron is rapidly oxidized; when dry, it is mixed with about five per cent. of charcoal powder; it is then slightly moistened with water and placed in the purifiers in a single layer two feet deep; when the mixture ceases to act upon the gas, it is withdrawn and exposed to the air, when it is rapidly regenerated, and may be used over and over again; the mixture now in use at the works has been in use since April 21st.

Q. Is that process effective as a purifier? A. I cannot say of my own knowledge, but have heard no complaints with regard to the quality of the gas.

Q. Does the mixture evolve any disagreeable odor after it is used? A. I have noticed none; I was there while the material was being taken out of the purifiers and shovelled over; I detected no odor of sulphide of ammonium or sulphuretted hydrogen.

Q. Is it more expensive than the dry-lime process? A. I should think not. The ore costs five dollars a ton, and is used again and again, while lime is used but once. I was informed that the New York Company spent from $18,000 to $19,000 a year for lime by the old process.

Q. Is this process used by the New York Company patented? A. The combination of ore, iron-turnings, and charcoal, is covered by a patent; but the use of iron-ore, or of the

oxide of iron, is not covered by a patent in this country, to the best of my knowledge. I would not say decidedly, for I have not consulted the patent records to ascertain, but I think not.

Q. State generally, from your information, what processes are in use in Europe? A. I have learned from numerous authorities that the iron process, either as Laming's process or as iron-ore, is used in most of the large cities of Europe.

Q. To your knowledge, have any of the commissioners sent to the Paris Exposition reported? A. Prof. J. Lawrence Smith, Professor of Chemistry in the Medical College at Louisville, and president of the Louisville Gas Company, made a report which, I am informed, was printed in the *American Gas-Light Journal*, though I have not seen it. I have in my possession a letter from him.

Q. As a matter of information, state what he says. A. He states that the oxide-of-iron process is generally used in all the cities of Europe. I do not like to say whether he says Europe or Continent without glancing at it.

Q. Does this process of purifying gas by iron-ore require any complicated apparatus? A. The usual dry-lime apparatus; of course some minor change, but no expensive change, in the apparatus is necessary.

Q. Is there any essential difference in the coal employed in this country and that employed in Europe, which would make a process which is successful there, unsuccessful here? A. I think not. I have analyzed numerous specimens of American coal, and do not remember that there was any thing peculiar in their composition; that is, the coal used for gas-making. We have a great deal of anthracite, but that is not involved in the question of gas-making.

Q. Generally, is it possible to obviate the present nuisance from gas-works? A. I think it is.

Q. How? A. By introducing the iron process of purifying.

Q. How long would it take, in any particular gas-works, to make the changes necessary —take the Metropolitan Gas Works, for instance—how long would it take to make these necessary changes? A. It is difficult to say how long; they would have to procure their oxides of iron. I should think two or three weeks.

Q. Would it interfere, meantime, with their manufacture? A. Not at all. Particularly as they have four idle purifiers. They could experiment on those without interfering at all with the four purifiers now employed for the dry-lime process.

Q. Are sulphuretted hydrogen gas and the sulphide of ammonium injurious to health? A. They are both poisonous gases.

Q. The question was, are they injurious to health? A. They are.

Q. Did you ever know any one to be injured by them? A. One of my assistants was rendered insensible by breathing sulphuretted hydrogen in the laboratory at Union College.

Q. Are all persons equally susceptible to them? A. No, they are not; my instructor in Berlin could not breathe sulphuretted hydrogen without getting a headache at once, while I have never suffered from it. Numerous instances have occurred in which persons have been killed by sulphuretted hydrogen.

Q. Why is sulphur removed from the gas at all? A. Because it produces *sulphurous acid*, the burning of which vitiates the atmosphere, and it also acts upon metals, brass, and copper, and would injure the brass fixtures.

Q. Why is the ammonia removed? A. If it is left in the gas, it produces *nitrous acid*, which would vitiate the atmosphere.

Q. Why is the carbonic acid removed? A. Because it diminishes the illuminating power of the gas.

Q. Is there any sanitary objection to the carbonic-acid gas being allowed to go through the main? A. I should say not, for the reason that the combustion of the perfectly purified gas would produce many times as much carbonic acid as would commonly be contained in it. Consequently the quantity in the gas is a very trifling matter.

Hearing adjourned to Thursday, August 13, 1868, at 11 o'clock A. M.

Prof. Chandler was cross-examined on February 6, 1869. *See page* 483.

MEMORIAL OF THE METROPOLITAN GAS-LIGHT COMPANY

To the Honorable the Metropolitan Board of Health:

The Metropolitan Gas-Light Company, of the City of New York, would respectfully represent that this company is the youngest of all the gas companies which supply the citizens of New York with gas; that its operations were commenced in the year 1863.

That its object from the beginning was to supply the consumers with pure gas, and to conduct its manufactory in the best manner, and according to the most approved methods science and experience could suggest.

That no complaint was ever made to this company that its method of purification of gas was offensive to the public, and that the first knowledge that the directors of this company had that your Board regarded its process of purification as injurious, was the order of the 14th day of July, 1868.

The undersigned respectfully submits that the method adopted by this company for the purification of the gas delivered by it to the consumers is such as is in use in all the large cities of the United States, and is such as this company has had good reason to believe was the best which science and experience could suggest to effect the object to be secured—the delivery of the best gas to the consumer, and manufactured in a way to be the least offensive.

The dry-lime process of purification used by this company is in general use by the gas-manufacturers in the United States, as best adapted to free the gas from all impurities and offensive elements and substances. This company is aware that other methods of purification have been resorted to by some English companies, and on the Continent of Europe, by the use of oxide of iron for this purpose. But, as at present advised, such method has not fully succeeded to the satisfaction of either the manufacturer, consumer, or the public. It is urged by the objectors that the gas delivered by such process of purification is not freed from the offensive elements which the dry-lime process removes, is impure, and injurious to the health of the consumer; and it is represented to the undersigned that companies in Europe which had adopted it, have abandoned it and gone back to the lime process.

This company has not yet had an opportunity to subject to a scientific and practical test the advantages of this method or others which may be suggested.

Unaware that any complaints were pending before your Board as to the operations of *this* company, and having no reason to believe that any just cause of complaint existed, it has heretofore used, as above mentioned, the lime process of purification.

Since the service on the company of the order of the Board of Health, declaring this company's method of purification to be a nuisance, some testimony has been taken before D. B. Hasbrouck, Esq., at the rooms of the Board of Health, in regard to the advantages of the lead process of purification, and also of the iron process, which examination is still pending, unconcluded.

The undersigned, most respectfully protesting against the adjudication of this Honorable Board, that their process of manufacture or purification of gas is a nuisance, still avow their entire willingness to try any method which science may suggest and experiment demonstrate to be a better one than that now in use. This company is not wedded to, and has no special interest for, the lime process of purification. If there is a better process it would gladly adopt it, so that it may manufacture gas in the least offensive manner, and deliver it to the consumer in the purest form.

This company submits that the mode of purification with the oxide of iron, or with iron in connection with other substances, is as yet an experiment only; and that such trial of its utility has not been had as to justify this company to abandon its present process, and incur the hazard and expense of adopting it.

It is true, as the undersigned are informed, that one of the companies in New York has lately experimented on the iron process of purification, but the experiments have been so recent that they cannot as yet be called a success, and would not justify the undersigned in adopting it without a trial by themselves.

This company would respectfully suggest to your Honorable Board, that all proceedings under the order of the Board, including the further taking of testimony, be suspended until

the Metropolitan Gas-Light Company shall have had time to subject the method of purification proposed, and other methods, to a practical test in its own works, and shall have had an opportunity to give the same a chemical examination by proper experts.

For this purpose the undersigned request a suspension of proceedings under the order, and the further taking of testimony, until the first day of March next.

This company is at present engaged in considerable improvements in extending its works, and cannot in justice to the subject, its own interest, and that of the consumers of its gas, before the time named, sufficiently and properly at its own works examine into and practically test the new method proposed. At the expiration of that time, this company will be prepared by experience to report to your Honorable body the result of such scientific examination and trial.

Should this company suspend operations in the manufacture and delivery of gas for a single day, the community would be subject to great inconvenience, this company to large fines, and its chartered rights be put in jeopardy.

It is submitted that time and opportunity should be granted to this company fairly to test by experiment the method of purification proposed; and should such trial and experiment prove that the method suggested is the best and freest from objections in regard to all the parties and interests affected, including the sanitary and healthful consideration of the matter, this company would gladly adopt it, or any other measure which judicious experiment should suggest.

The directors and corporators of this company are residents of the city of New York, and in common with all other citizens are interested in the health of its inhabitants.

This company would do nothing to endanger the health of the city, and will do all in its power so to conduct its business in the mean time as to invoke no unfavorable action on the part of this Board, nor any complaint from any citizen.

All of which is respectfully submitted on behalf of the Metropolitan Gas-Light Company:

H. C. VAN VORST, *Of Counsel.*

O. ZOLLIKOFFER, *President.*

NEW YORK, *August* 17, 1868.

The hearing in the case was postponed to December 1, 1868, in order to give the Gas Company an opportunity to make the necessary experiments and changes.

SECOND MEMORIAL OF THE METROPOLITAN GAS-LIGHT COMPANY.

OFFICE OF THE METROPOLITAN GAS-LIGHT COMPANY, NEW YORK.

To the Honorable the Board of Health:

The undersigned, the President of the Metropolitan Gas-Light Company, had the honor heretofore to address to your Board a memorial in behalf of this company, in respect to certain proceedings pending before the Board of Health in respect to the method used by this company in the purification of gas.

This company, desirous of doing every thing proper to be done, so that the gas they manufacture may be delivered to the consumers freest from injurious elements, and so as to be least objectionable to the public in the process of its manufacture and purification, evoked the postponement of all proceedings before the Board of Health until the first day of March next.

This company, intending in the mean time to obtain the most reliable information to be had in this country and in Europe, in regard to the best method of manufacturing and purifying gas, considered chiefly in a sanitary point of view, and to avail itself of the best experience to be had on this subject, and to make proper experiments itself: this company thought the time evoked was not unreasonable, especially as it would occur in the season of the year when the least complaint could be made of unpleasant odors in the atmosphere, and when little if any inconvenience could be experienced from this source, your Board postponed all proceedings until the first day of December, instant.

In the mean time this company had sent to Europe an expert to observe the methods in use in the purification of illuminating gas in the chief capitals there, and to gain and report to this Board the result of such investigations, especially in its sanitary relations to this subject. The person so sent is a distinguished chemist; he is now prosecuting his inquiries abroad, and is expected to bring back to this company within a short time valuable information in respect to this matter.

The President of this company attended at the Board of Health on the 1st of December last, to make such statement, and to ask a further postponement until the 1st day of March next of the proceedings; but the Board of Health was not in session, nor was there in attendance the officer of the Board who had the matter in charge.

This company, therefore, again ask the Board of Health to postpone all proceedings until the 1st of March next.

In the mean time this company will have received the desired information from abroad, and will have made additional tests and experiments.

In closing this communication, this company again suggest to your Honorable Body that the method of purification in use by them—the dry-lime process—is such as is in general use in the city of Philadelphia, and in all the chief cities of the United States; that it is by no means established that the process of purification by iron is free from disagreeable or noxious vapors, but, on the contrary, it is claimed by chemists and persons well informed that the gas delivered by that process of purification to consumers has a greatly diminished illuminating power; that it is not eliminated from elements injurious in their effects to the consumer, and which the lime process entirely removes.

This company would hesitate to pronounce decidedly upon this matter at this moment, and only desires to avail itself of the best experience, and the latest improvements in science and manufacture, to deliver the best and purest gas, and manufacture it in a manner the least objectionable, and will be glad to coöperate with the Board of Health in this regard, and your petitioner will ever pray.

O. ZOLLIKOFFER,

Dated NEW YORK, *December* 16, 1868. *President.*

The hearing was again postponed at the earnest request of the Gas-Light Company to February 1, 1869.

On February 6, 1869, the Gas-Light Company having made no changes in their process of manufacture, the hearing was resumed.

CONTINUATION OF THE HEARING BEFORE J. C. HAWLEY, REFEREE.

NEW YORK, *February* 6, 1869—1 P. M.

Professor Chas. F. Chandler, recalled and cross-examined by ex-Judge H. C. Van Vorst, testified as follows:

Q. Have you given much attention to the chemistry of illuminating gas? A. I have been interested in the chemistry of gas to a greater or less extent for the last fourteen years.

Q. Have you had occasion to visit many gas-works? A. Quite a number.

Q. In Europe? A. Some in Europe.

Q. In this country? A. In this country.

Q. Have you visited the Philadelphia gas-works? A. I think I did visit them, but I have not a very definite recollection. I saw all the sights in Philadelphia that interest chemists. I think I have visited the gas-works there.

Q. Can you state what process is in use in the United States for the purification of gas? A. The dry-lime or the wet-lime process.

Q. Which generally? A. The dry-lime, I think.

Q. How extensively does that prevail? A. Almost entirely.

Q. Are you acquainted with any exceptions to it? A. The New York Gas Company of this city, and two or three companies in New England.

Q. Can you say where those gas companies in New England are located, that use any other process except the dry-lime process? A. I should not like to say definitely.

Q. You don't know? A. I have seen statements and letters from parties using the other process; but I have not interested myself sufficiently on that point to ascertain.

Q. Can you say then that any process for purification, except the dry-lime process, is used of your own knowledge, by any other company except the New York company, to which you have alluded? A. I have not seen it—no.

Q. Nor can you mention by name any other company in any place that uses any other process, except the lime process? A. Well, I think the Worcester and the Malden are using the iron process.

Q. Do you know that they do? A. I have been so informed. I think those companies were the ones.

Q. You think you have been informed? A. I have been informed that companies were using it, but my memory is a little uncertain as to which companies they were.

Q. In the United States? A. Yes, sir; but I am a little uncertain as to which.

Q. Except the New York company? A. Yes, sir.

Q. Do you know Professor J. Lawrence Smith, of Louisville? A. I do—yes, sir.

Q. You have spoken about him on your direct examination? A. I have.

Q. Have you received some communication from him? A. Yes, sir.

Q. He is the President of the gas company at Louisville? A. Yes, sir.

Q. Do you know what process of purification is adopted in his company? A. I suppose the dry-lime process.

Q. You suppose that this is in use in his company? A. Yes, sir.

Q. Did you then mention all the elements of crude gas?* A. I think not. It was not my intention to mention them all.

Q. What elements do you now state to be in the crude gas which you did not then state? A. There is such an indefinite number found in the gas, and I have mentioned only those most important, that I should have to refer to my evidence to say which I did mention. I do not recall any important constituent that I should like to add to this list.

Q. There are none that you desire to add to it? A. No.

Q. Did you regard carbolic acid, or phenol, as important? A. I did not.

Q. Is it a constituent of crude gas? A. There are minute traces of it in the crude gas.

Q. Have you visited the Manhattan works? A. I have.

Q. Did you not then discover the presence of phenol—indications of it? A. There was a slight odor which might be called that (phenol), and it might be a dozen other things—not with certainty.

Q. Where did you discover that? A. I may say that there was a substance there that one of my companions† pronounced to be phenol, though I did not feel certain about it. It was discovered about the spent lime which had been used to purify the air drawn from the main purifiers; also in the air which the Manhattan Company was allowing to pass into the atmosphere, in which we also discovered sulphuretted hydrogen.

Q. When you say in your testimony that the waste lime contains but small quantities of ammonia, do you include that contained in sulphide of ammonium or only free ammonia? A. I include ammonia in all forms.

Q. Is there not such an excess of ammonia in all cases that all the ammonia must be in the form of sulphide of ammonium? *Witness.*—Do you mean in the gas or refuse lime? *Counsel.*—Refuse lime. A. No; I think not.

Q. Why not? A. Because there is an excess of lime there.

Q. Is there much naphthaline in the waste lime? A. There is some naphthaline.

Q. Not much? A. No, I should say not much.

Q. Have you visited the Manhattan works since your direct examination? A. Yes, sir.

Q. Have or have not your views of the constitution of waste lime been modified by your observations during your visit to the Manhattan works—waste lime as spoken of in your tes-

* Referring to Prof. Chandler's former testimony.

† Prof. Wurtz.

timony? Your testimony was given with regard to the character of waste lime after it had acted as an agent in the purification of gas. A. Then my views have not changed with regard to the character of waste lime in general.

Q. Has it in any regard changed? A. It has changed somewhat in regard to the waste lime of the Manhattan Gas Company.

Q. How so? In what regard has it changed? A. I don't consider the waste lime of the Manhattan Gas Company nearly as offensive or as liable to produce a nuisance as that of companies not employing the process used there.

Q. What do you understand by the term nuisance?—you use the word. A. Something so disagreeable to the senses or the sense of smell, in this case, as to cause complaint.

Q. Can you move in any direction in the city without incurring something which is disagreeable to the sense of smell? A. Yes, sir. I walk up Fifth Avenue frequently without smelling any disagreeable smell.

Q. Is that the only exception you make? A. No.

Q. Generally? A. Nuisances are by no means rare, and they differ in degree.

Q. Generally speaking, now, with regard to moving in any direction, persons that have delicate olfactory nerves—can they go anywhere in the city without meeting something which is disagreeable to the sense of smell? A. No, I should think not.

Q. In the order of nature and the economy of the management of cities those odors are constantly being evolved? A. Yes, sir, to a greater or less extent.

Q. From a variety of causes? A. Yes, sir.

Q. Is there not, as yet, much obscurity in the minds of the chemists generally about the complete nature of the action of the lime—the complete composition of the waste and the effluvia therefrom? A. I think the main principles are pretty well settled. There is a difference of opinion about the details and the minor reactions that take place.

Q. Is there not much obscurity still? A. There is, about the minor changes that take place.

Q. Do not these require yet considerable analysis and investigation to reduce our knowledge to precision for scientific purposes? A. They do. For sanitary purposes they do not.

Q. Is it not reasonable, doctor, even for sanitary purposes, to expect such investigation would develop important improvements in the use of the dry-lime process by which its offensive features, of which you have spoken, may be removed? A. I have no wish to predict the success of the future investigations in that direction.

Q. Don't you think that there is any thing about it that would warrant any such conclusion as that? A. Only as far as the investigations are liable to result in improvement.

Q. Is there any thing in the subject-matter itself which would warrant such a conclusion as that? A. Conclusion to what effect?

Q. By which the offensive features of the dry-lime process may be removed. A. I have already alluded to the fact that a process is in use in New York, in which the offensiveness is to a great extent removed.

Q. That is the Manhattan Gas Company? A. Yes, sir.

Q. Aside from that? A. Aside from that I have no reason to have an opinion one way or another.

Q. In reply to the question as to what occurs when the spent lime is exposed—the lime that has performed the office of purifying the gas—you described three or four actions, which of these predominates? A. These reactions succeed each other so that it is difficult to answer that question directly.

Q. Which predominates? A. Ultimately the oxidation of the sulphide of calcium predominates.

Q. Does not the oxidizing action predominate, as shown by the heat evolved? A. The heat evolved would not prove any thing with regard to the comparative reactions which take place.

Q. Then you infer that the oxidating action predominates otherwise than is exhibited by the heat? A. Yes, sir.

Q. It does predominate? A. I infer that it predominates, from the fact that the sulphide of calcium is the predominating substance susceptible of change.

Q. Does the atmosphere contain enough carbonic acid to give prominence to the other two actions you suppose? A. It does.

Q. Would not the oxidating action occur with the sulphide of ammonium as well as with the sulphide of calcium, converting it into hyposulphite or sulphite of ammonia? A. I would infer from my laboratory experience that sulphide of ammonium is evolved directly into the atmosphere without undergoing material change.

Q. And you speak from no other experience except that, in that connection? A. Yes, sir.

Q. Except your laboratory experience? A. Yes, sir.

Q. Is not sulphide of ammonium a very unstable, perishable, and transient substance in the air? A. While I have no doubt that it ultimately undergoes decomposition in the air, I know, from years of experience, that it remains intact long enough, for a considerable length of time, as shown by its persistent odor.

Q. Where was that experience obtained? In the laboratory? A. In the laboratory.

Q. I am now speaking about the external air, outside of the laboratory. A. It don't make any difference on that point.

Q. Is it any more perishable in the external air than it is in the laboratory? A. No.

Q. Is it not more readily dissipated? A. Distributed, of course.

Q. You were talking about decomposition, and not distribution. It is decomposed more readily in the external air? A. It is not.

Q. But it is distributed more readily? A. Undoubtedly, if the wind is blowing, it is distributed more readily than if shut up in the room.

Q. But is not lost. A. Do you mean by decomposition?

Q. In any way? A. It is lost if it is carried off by the wind, of course.

Q. And that is the only way in which it can be destroyed? A. I have already stated that it may undergo decomposition.

Q. How may it undergo decomposition? A. I am not prepared to give the definite decomposition that might take place.

Q. Is it likely to undergo decomposition? A. I should think it might be.

Q. How soon? A. I can't say.

Q. How soon after being evolved? A. I can't say how soon.

Q. Have you no idea? A. No definite idea.

Q. Is chemistry unable to furnish any solution of the manner in which it is decomposed, or the time in which it may be decomposed in the external air? A. Probably it is able to do so. I don't claim to carry all the facts of science in my head.

Q. I want only to know, as far as your experience goes, whether chemistry can determine that question—as far as you know? A. I can only say that I have not studied up that particular point.

Q. Is not sulphuretted hydrogen quickly destroyed by the air? A. Yes, sir, ultimately—I suppose so. Sulphuretted hydrogen would be oxidized by the air.

Q. You make substantially the same answer to that you do to sulphide of ammonium—that it becomes decomposed after a while? A. Yes, sir, I suppose so.

Q. Within what time after its evolution? A. That I can't say.

Q. Sulphide of ammonium being volatile, would it not be necessarily decomposed by contact with the large excess of caustic lime left in the spent lime? A. It may be partially decomposed, but I think it is not completely decomposed.

Q. To what extent? A. I have no data to say—to decide.

Q. Would not ammonia be thus set free and the sulphide of calcium formed? A. That reaction might occur to some extent.

Q. Is it not a necessary consequence? You say it might. A. It is not a necessary consequence, because the hydrate of lime in the spent lime is so protected that it is not capable of exerting the action which it would exert under other circumstances, as shown by the fact that it is impossible to change all the hydrate of lime in the purifiers.

Q. Is pure ammonia offensive? A. Not in moderate quantities.

Q. In quantities which are given off from such spent lime would it not be? A. No.

Q. Is the ammonia from the stables offensive? A. Pure ammonia from the stables is not offensive.

Q. Nor deleterious to health? A. No.

Q. On the other hand, is it not regarded for certain complaints as healthful? A. I should not care to answer the question in regard to that—that is to say whether it is healthful, or not. I should not like to say about that. I believe it is; I am not a physician.

Q. But you don't regard it as deleterious to health? A. I shouldn't consider it so.

Q. You have spoken with some degree of favor, in your direct testimony, of the kinds of oxide-of-iron methods, and especially of the Laming process? A. Yes, sir.

Q. Do you believe that these methods are equal in purifying the gas from sulphur to the lime process? A. Not having investigated that point myself, and finding a difference of opinion among authorities, I am not in a position to answer the question definitely.

Q. I should like to have your opinion on that subject as an expert. A. It is my opinion that, while the lime process may take out a little more sulphur than the oxide-of-iron process, that the difference in the effect of the two is not sufficient to counterbalance the other advantages of the iron process. There are several iron processes.

Q. In your opinion, then—I am going back to the question, because you have brought in other matters which I have no objection to, at all—I ask you then, in your opinion, whether they are equal—these two processes, the lime and the iron—equal in purifying the gas from sulphur? A. I think there is a slight advantage in favor of the lime process.

Q. Does the iron method extract the sulphur which is in the form of bisulphide of carbon? A. That question has never been determined by experiment, to my knowledge.

Q. You can't answer the question? A. No; not to my knowledge.

Q. Does it take out phenol? A. I should make the same answer to that question that I made to the other.

Q. Does the iron process take it out? A. It does not.

Q. Do you mean that lime takes it out of the crude gas? A. Yes, sir; it probably takes out at least a portion of it.

Q. But you can't say the iron takes out any? A. Not with certainty.

Q. You did discover in the Manhattan Works evidence that the phenol had been taken out—what you supposed to be phenol? A. No; I did not suppose it to be phenol; that is, there was an odor there that reminds one of phenol, but I do not consider that in sufficient quantity to establish its identity.

Q. What could it have been if it was not phenol? A. A hundred other things. The number of substances occurring in gas is so little known that it is not safe to decide from the slight resemblance in odor.

Q. I understand you to say that the lime process would eliminate the phenol? A. I think it would probably remove some of the phenol.

Q. How can the oxide-of-iron method take out the ammonia from the crude gas? A. I never said it could.

Q. It can't take it out, then? A. The ammonia is taken out before it comes to the oxide of iron.

Q. Does the oxide of iron take it out at all? A. I think it probably does hold a little ammonia. There is not much in the gas by the time it reaches the oxide of iron. The oxide of iron might withdraw a small quantity of ammonia if there was any in the gas.

Q. Before it left the purifier? A. Yes, sir, it might do it.

Q. Can't you say with certainty? A. I know there is an affinity between oxide of iron and ammonia, and, judging from that, I should suppose it would, and, moreover, the oxide of iron smells of ammonia.

Q. I understand from your testimony that you speak doubtfully of the entire removal of carbonic acid by Laming's method? A. I don't think there is so much doubt about the removal of carbonic acid by Laming's method. He don't use the hydrate of lime because he uses the hydrate of lime with the oxide of iron.

Q. Suppose it was subjected merely to the action of the oxide of iron without the hydrate of lime subsequently. What then with regard to carbonic acid? A. The removal of the

carbonic acid would then depend on the possible action of the little ammonia which might be absorbed by the oxide of iron.

Q. Could the gas be subjected to the purification of hydrate of lime subsequent to the iron process, without serious detriment to the candle-power of the gas? A. I think it might.

Q. It has been stated that the iron process does not remove the carbonic acid completely. Is that so? Has it never been so stated? A. One of your chemical advisers, who is one of the persons that I understand you propose to bring in, has made that statement.

Q. Who do you refer to? A. Professor Wurtz.

Q. Have you not yourself so stated? A. I believe I did.

Q. Was it true? A. I gave it as an opinion merely.

Q. Have you any reason to change your opinion from that? A. No.

Q. Have you visited the New York Works? A. I have.

Q. Do you regard the Rev. Mr. Bowditch as good authority on the use of coal-gas, and the chemistry of coal-gas? A. I do, except so far as he has a process of his own for purifying gas.

Q. Is he not regarded as an authority? A. With that limitation, yes, sir.

Q. Do you say that there is no disagreeable odor or smell proceeding from the oxide of iron, after it has been used to purify the gas? A. There is not a sufficient amount of odor to constitute a nuisance, as I judge from my own experience.

Q. How much do you think it takes to constitute a nuisance? A. Enough to be offensive; it would probably make some difference what oxide-of-iron process is employed, as there are several.

Q. The oxide-of-iron process at the New York Works? A. That is the one I speak of when I say it is not offensive.

Q. Mr. Bowditch, in his work on coal-gas, states as follows on page 21, with regard to this process of purification with the oxide of iron: "That it has its drawbacks for consumers: 1. Because, since it came into use, much carbonic acid is left in gas, and thus its illuminating power is reduced; 2. Because when the fouled oxide is brought out to revivify, it gives off a quantity of very offensive compounds which seriously annoy those who reside in the neighborhood of works where fouled oxide is exposed to revivify in the free air instead of covered or nearly-closed vessels and chambers." Do you agree with Mr. Bowditch in that? A. I don't, nor do any of the authorities that I have consulted.

Q. To what part of it do you not agree? A. The nuisance of the revivification of the spent iron oxide.

Q. Is that the only part you don't agree with? A. Yes, sir.

Q. You don't disagree with him then in what he says in regard to the carbonic acid being left in the gas? A. No.

Q. The Rev. Mr. Bowditch says in his work as follows: "The aqueous vapors and the vapors of hydro-carbons, are much heavier than the atmosphere, and when evolved from the foul oxide by the heat of chemical action, they float in the lower stratum of the atmosphere near the surface of the earth and produce extensive annoyance." What do you think about that? A. The Rev. Mr. Bowditch makes a mistake. One portion of the statement is directly at variance with the facts of the case, for aqueous vapor is only two-thirds as heavy as atmospheric air.

Q. Would not the fog arising from these purifiers of oxide of iron be heavier than the air? A. If it was heavier than the air, it would not rise. So there is an inconsistency in your question which makes it difficult for me to answer it.

Q. The theory is that it remains floating in the lower stratum of the atmosphere near the surface of the earth; would not that fog arising from these purifiers float in the lower stratum of the atmosphere near the surface of the earth? A. That would depend on the condition of the atmosphere at the time as to the movement of the currents.

Q. Well, generally—the general condition of the atmosphere. We don't want exceptional cases? A. I can only answer from experience that there is not any marked accumulation of gases about the neighborhoood of works using this process.

Q. Are not hydro-carbon vapors heavier than the atmosphere? A. Some are, and some are not.

Q. Those which are evolved from these purifiers (because I am only speaking about those, it is not in a general broad field)? A. I think they are, probably.

Q. How do you reconcile the assertion that has been made by the promoters of the iron process of the entire suppression of the disagreeable smell, with the wholly opposite statements made by other authorities? A. The only opposite assertions made by any other authority that I know of are made by the Rev. Dr. Bowditch, who has a process of purification of his own to recommend, and, as my own experience agrees with the statements of all the other authorities I have consulted, I am at a loss to account for the Rev. Mr. Bowditch's opinion.

Q. Then you know of no other authority than Mr. Bowditch who speaks of the disagreeable odors proceeding from the fouled oxide of iron? A. I recollect of no authority who speaks of them as at all a nuisance.

Q. Does not Clegg say the same thing, sir, with regard to the oxide of iron—of the disagreeable odors arising from it? A. I don't recollect that he does.

Q. He is a good authority, is he not? A. Certainly.

Q. You don't recollect that he speaks of such odors proceeding from the fouled oxide of iron? A. I have not consulted Clegg since last summer.

Q. Since your evidence was rendered have you heard any complaint respecting the quality of gas delivered by the New York Gas-Light Company throughout their district? A. I saw a complaint in the newspaper which emanated from the laboratory of the chemist of the Manhattan Gas Company. It mentioned tests made in his laboratory.

Q. Is that the only complaint you have heard of the quality of the gas? A. I have on one other occasion seen a statement in the newspaper to the effect that something had gone wrong at the gas-works, by which the consumers were deprived of their supply of light.

Q. Haven't you heard it stated, with regard to the gas, that it was not very pure gas, that it had sulphur? A. Only in this instance, which came from the agents of another Gas Company.

Q. Have you tested the gas delivered by that Company * for the purpose of discovering whether there was any, and if so, what amount of sulphur in the gas as delivered by it? A. I have.

Q. What was the result of your investigations on that subject, did you discover sulphur? A. I discovered sulphur every time.

Q. How often did you make those experiments? A. I have tested the gas on four or five different occasions.

Q. What method did you adopt to discover the presence of sulphur? A. The combustion method usually employed. I have also used test-paper repeatedly without discovering sulphuretted hydrogen.

Q. What quality or proportion of sulphur did you discover on that occasion? A. The quantity varied.

Q. The sulphur was there, I suppose. The occasion of the sulphur being there was on account of the imperfect method of the purification of the gas, was it not? A. All gas contains sulphur; gas is never perfectly purified.

Q. That is not the question. If it was perfectly purified, it would be taken out. The method of purification was imperfect, was it not? A. Yes, sir. It makes me tell something which does not represent the truth when you make me answer that with a single word.

Q. How much sulphur did you discover? A. I find I have more tests here. I said four or five times, but I had forgotten how many. The quantities of sulphur found in the gas varied from 21 to 45 grains per 100 cubic feet.

Q. That is more than is allowed by the English Parliamentary standard, is it not? A. Yes.

Q. The English Parliament allows what percentage in the gas? A. 20 grains.

Q. And, therefore, you found more there than is allowed by the English standard? A. Yes, sir.

* The New York Gas-Light Company is the one here referred to.

Q. Now, I am going to ask you this question. You use the gas delivered by the Metropolitan Gas Light Company, do you not? A. Yes, sir.

Q. Have you tested it to see whether there is any sulphur in it? A. I have not.

Q. But you have used it in your house? A. Yes, sir.

Q. Have you discovered any sulphur in it? A. I know there is sulphur in it. I should state so, that I may not appear to misrepresent the facts of the case. I have made some experiments on the Manhattan and Metropolitan gas, but the results determined have not been weighed, so that I cannot tell the figures. The examinations have not been completed.

Q. You say that you discovered sulphur? A. Yes, sir, there is sulphur in both.

Q. As they deliver it now? A. Yes, sir.

Q. The gas delivered in your house you have not specifically tested to discover whether it contained sulphur or not? A. It was tested in my laboratory, but not in my house, but the quantity I have not determined in either case.

Q. It is appreciable, is it? A. Yes, sir.

Q. I am going to ask you as an expert from what you have known of these various systems of purification, and what you know of the subject-matter, as an expert would you advise the Metropolitan Gas-Light Company to adopt the iron process without very mature and deliberate inquiry and examination and experiments? A. I not only would advise them to do it, but I did advise them to fill their four purifiers with the iron mixture and give the thing a fair trial at once.

Q. You do advise them to do so? A. I do, and I suggested that they should do it.

Q. The question as I propounded it to you is whether you would advise them to adopt the iron process without mature and deliberate examination, inquiry, and experiment? A. I should. There are reasons why I should.

Q. I will allow you to give your reasons. A. These reasons are so trifling that it is scarcely worth while to put them on record.

Q. I should like to have them down? A. In the first place, I consider the iron process more economical. In the second place, it would do away with the cause of this hearing.

Q. That would be entirely satisfactory to the Board of Health? A. I am not at liberty to speak for the Board of Health, and I am not the prosecuting attorney.

Q. You think it would do away with the hearing? A. I think it would do away with the nuisance, and if it did away with the nuisance there would not be a cause of complaint. That is my opinion as an expert.

Q. Do you know whether the officers of the New York Company are not dissatisfied with this method of the purification of gas, and that it does not come up to their expectations in that regard? A. On the contrary, I know that they are pleased with the process.

Q. Did you ever know or hear of an employé or visitor in any of the gas-works being killed by the effluvia from the fouled purifiers? A. I think I have heard of such cases, but I could not say with absolute certainty that the sulphuretted hydrogen which killed them was from fouled purifiers, or some other chemical source. I have heard of persons being killed by escaped sulphuretted hydrogen, but I am a little uncertain whether it occurred in gas-houses or elsewhere.

Q. I did not ask you that. A. I am a little uncertain whether it occurred in the gas-house or where.

Q. Did you ever know or hear of an employé or visitor in any gas-works being killed by the effluvia from the fouled purifiers? A. I have heard of persons being killed by such foul gases, but I am a little uncertain whether it occured in gas-houses or not.

Q. Or on gas premises? A. Or on gas premises.

Q. Or that the vapor escaped from the manufacture of gas? A. Yes, sir.

Q. You can't say that it was. It may have been sulphuretted hydrogen formed under other circumstances? A. Yes, sir.

Q. Do not mineral poisons, where frequently administered, generally produce some specific disease—salivation, ulceration, etc., etc.? A. Some do, and some do not.

Q. Which mineral poisons do not? A. Salt—common salt.

Q. Otherwise, do you make any other exception? A. Yes, an indefinite number of exceptions.

Q. Mercury? A. Mercury, in a sufficient quantity, will salivate, certainly.

Q. Phosphorus? A. If you breathe enough of it, it will produce caries of the jaw.

Q. Lead produces diseases, does it not? A. Yes, sir.

Q. Palsy and colic? A. Yes, sir; and paralysis.

Q. Does not the bisulphide of carbon produce a similar disease? A. I can only speak from my own experience in that case; that I have been in the habit of breathing bisulphide of carbon frequently, and never suffered any injury from it.

Q. State, aside from your own individual experience as a chemist, how is it? A. Bisulphide of carbon is used so much for filling prisms, and employed by experimenters, and the fact that I have not known it to produce any ill effects, leaves me in doubt of its producing any. I have had it about my own house months together, so that you could perceive it in coming in the neighborhood of it, and never knew of any evil effects from it.

Q. In factories, haven't you heard of operatives getting disease from it? A. Never. I never read of it. Some of my old pupils are manufacturers of it too, and I know they do not suffer any injury from it.

Q. According to your own experience, are the employés in purifying-houses of gas-works subject to any special disease or diseases? A. They are not.

Q. Now, in the cases on record of the poisonous effect from sulphuretted hydrogen, was not the proportion in the air breathed very far greater than any ever occurring in a purifying-house, much less in its neighborhood merely? A. It was.

Q. Which do you suppose to be the worse—free sulphuretted hydrogen or sulphide of ammonium? A. I don't see much choice between them.

Q. You can't say which is the worst? A. No.

Q. Is there any? A. I can't say.

Q. Have you ever heard of any person being injured by sulphide of ammonium? A. I have not. It is a much rarer substance than sulphuretted hydrogen.

Q. Can there be really any sulphuretted hydrogen at all given off by the waste lime, considering that the predominant odor is that of ammonia? A. I could not answer that question.

Q. This is a bottle of spent lime taken from the purifier of the Metropolitan works. Now the question is, if you will tell us what is the predominating odor? A. Ammonia. The odor of the second one is that peculiar persistent odor of gas-lime, which has not been investigated to such an extent as to make it possible to state exactly what it is.

[The counsel produces two bottles of spent lime taken, one from the top and the other from the bottom of a fouled purifier of the Metropolitan Gas Works.]

Q. Is there ammonia there also, doctor? A. I think I perceive ammonia.

Q. Try it again. A. I think there is ammonia there.

Q. Is there not an excess of ammonia? A. I think there probably is.

Q. Try, doctor, long enough to know whether there is an excess of ammonia there. A. I think there is probably some ammonia there.

Q. An excess of it? A. I think so.

Q. Is there any doubt about it? A. I think not.

Q. You have subjected it to another test? A. Yes, sir.

Q. To what test? A. Turmeric paper.

Q. Doctor, can there really be any free sulphuretted hydrogen of the kind supposed to be thrown off by the waste lime, considering that the predominant odor is that of ammonia? A. Not until after the ammonia has escaped.

Q. Is there any evidence that there is any poisonous substance given off by that lime? A. Yes, sir, I think there is.

Q. What is it? A. I think there is sulphide of ammonium escaping from the mixture.

Q. Did you ever know of sulphide of ammonium poisoning anybody? A. No, I never did.

Q. Did you ever hear of anybody being poisoned by it? A. None.

Q. Then why did you say it is poisonous? A. Because it has such a disagreeable effect on my nose and lungs.

Q. Is not almost every human being subject every day more or less to the inhalation o sulphide of ammonium, or even at times sulphuretted hydrogen, from his own excrement? A. He probably is.

Q. Are scavengers who handle such matter subject to any special morbid condition? A. They are occasionally killed by the foul gases of the cesspools they enter.

Q. Are they subject to any special morbid condition? A. Would death come under that head? They are occasionally killed by the effluvia.

Q. That is the only answer you can give to it? A. Yes, sir.

Q. Is it not an accepted maxim that the effluvia from human excrements, unless putrid or tainted with a disease like cholera, never hurt any person? A. I never heard any maxim relating to it, but I never knew the fresh excrements to do any harm. After a short time they certainly do have that effect. We know that the camps during the war became terribly offensive from the accumulation of that sort of thing.

Q. Is not sulphide of ammonium a recognized constituent of the effluvia from such substances? A. I can only say that I have not paid especial attention to that department of science.

Q. What is the effect of leaving sulphur compounds in gas? A. That depends somewhat on what particular compounds are left in the gas.

Q. Sulphur compounds? A. There are different sulphur compounds; some have one action, some another.

Q. When the gas is burned? A. When combustion takes place they produce sulphurous acid and sulphate of ammonia.

Q. Is that first product of which you speak deleterious to health or not? A. Not in the small quantities which are evolved from the wholly purified gas.

Q. Gas that contains 21 grains? A. No, sir.

Q. Not injurious to health? A. No, sir.

Q. Nor detrimental? A. No, sir.

Q. Or to property? How does it affect property? A. Or to property.

Q. What was the experience in the early days before the lime process was introduced, in regard to the effect of gas-light on health and property? A. The enormous quantity of sulphur in the gas at that time was a source of inconvenience, I believe.

Q. Didn't it injure property, books, and maps? A. It was claimed that books suffered from it.

Q. Was not its use prohibited in the British Museum? A. I cannot say that it was.

Q. Is there not an especial danger pertaining to sulphurous acid gas, arising from its comparative freedom from odor? A. It is not comparatively free from odor.

Q. You deny the premises? A. I deny the premises. It has, on the contrary, a most suffocating odor.

Q. What is the effect of it upon your eyes, lungs, and mouth? A. In a concentrated form it is suffocating, and, in the small quantities which gas is liable to put in the atmosphere, it is inappreciable. I have not smelled or perceived the sulphurous acid, even from the most impure gas that I ever saw burned.

Q. Do chemists hesitate to expose themselves to sulphuretted hydrogen or sulphide of ammonium? A. Not when they are diluted.

Q. Do they hesitate to inhale sulphurous acid? A. Not when it is diluted.

Q. Do you make any distinction between them? A. No, sir.

Q. Do they hesitate any more to expose themselves to inhaling sulphurous acid than they do sulphuretted hydrogen or sulphide of ammonium? A. Only in so far as the sulphuretted hydrogen or sulphide of ammonium is more disagreeable when presented in small quantity.

Q. Are they as injurious as the other? A. In minute quantities, I consider that sulphuretted hydrogen and sulphide of ammonium are most injurious.

Q. What is the action of lime on the bisulphide of carbon in the gas? A. I don't know that it has any action.

Q. What is the action of oxide of iron on it? A. I don't know that it has any action; I answer your question, supposing you to mean at ordinary temperatures.

Q. The Rev. Mr. Bowditch says, in his work, on page 27: "At common temperatures hydrate of lime forms, with bisulphide of carbon, a very beautiful ruby-colored crystalline salt." Do you agree with the Rev. Mr. Bowditch in that? A. I have never examined the question.

Q. You don't know whether he is correct or not there? A. No.

Q. Do you know Berzelius? A. I have read him.

Q. Is he a good authority? A. Yes, sir.

Q. Berzelius says: "By digesting sulphide of calcium with an excess of bisulphide of carbon and water at 30 degrees in a glass vessel, a dark ruby liquid is obtained, and this, when evaporated in vacuo, yields a mass which is yellow, brown, and crystalline, at first, but assumes a pale-yellow color when perfectly dry." Do you agree with Berzelius? A. Yes, sir; I accept whatever Berzelius says, unless I know to the contrary.

Q. If you accept that, does it not necessarily follow that the lime-purifier extracts the bisulphide of carbon? A. It doesn't necessarily follow.

Q. Why not? A. In the first place, the conditions were not the same.

Q. If the conditions were the same? A. If the conditions were the same, and there was no other reason for some other change taking place, that might happen.

Q. What conditions are not the same? A. In the first place, Berzelius had an excess of water; he speaks particularly of the excess of water; that might or might not modify the reaction.

Q. I understand you to admit that the Rev. Mr. Bowditch states that at a common temperature hydrate of lime forms with bisulphide of carbon a very beautiful ruby-colored crystalline salt? A. I accept that substantially.

Q. Now, if you accept that, and if that is true, will not the lime process extract the bisulphide of carbon? A. It will probably extract a portion of it.

Q. Are you aware that the Metropolitan Gas Company scrub their gas copiously with cold water before condensing it? A. I am aware of it.

Q. I want you to say what effect has this scrubbing on the offensive compounds? A. It undoubtedly removes a portion of them.

Q. It carries them off, those at least which are condensable in water, into the tar-well? A. A portion of them, not all of them.

Q. That proportion of course is prevented from going into the purifiers at all? A. Yes, sir,

Q. What effect would it have, for example, on the acetylene in the gas, would it not remove it? A. It would probably remove a portion of it; it don't take all of any thing out of the gas.

Q. Does it not take out the tar? A. A portion of it; the greater portion of it. I should qualify that, because a very small portion of tar goes to the water at all; it is separated before the scrubbing by water is resorted to, and I suppose it takes out a very small portion of the tar.

Q. Would not the washing with water increase the quantity of tar in the water itself which was extracted? A. The water would extract a little more, which would otherwise be left in the gas.

Q. Does not the tar contain all the offensive ingredients of the gas? A. It contains portions of most of them; that is to say, the impurities are not all in the tar.

Q. Then this scrubbing process does perform a very sensible office in the purifying of the gas? A. Yes, sir.

Q. And of course prevents them from going into the purifiers with the waste lime? A. Yes, sir.

Q. Otherwise, if they went into the waste lime there would be more work done there, and that process purifies the gas to that extent at any rate? A. Yes.

Q. The washing process, to a considerable extent? A. Yes, sir.

Q. If you put a woollen cloth or blanket in the atmosphere containing these foul vapors, will it not absorb and contain them for a considerable time? A. I suppose it would.

Q. Is there any doubt about it? A. No, I think not; I think it would.

Q. What are the properties of acetylene as to smell? A. I believe it has a disagreeable odor; but I never smelled it.

Q. Do you know what becomes of it when the gas is burned? A. I suppose it is burned in the gas.

Q. Do you consider Berthelot good authority? A. He is a noted chemist.

Q. Berthelot says that "coal-gas is no exception to this general rule—a rule that has been stated—as may be easily ascertained by observing the traces of acetylene which it contains in its normal state. It is produced and discharged into the atmosphere whenever an organic compound burns in contact with the air with the formation of lamp-black." Do you agree with Berthelot in what he says about that? A. I can only say that I have often perceived that odor which Berthelot attributes to acetylene, but have no other evidence in the matter.

Q. Berthelot says further as follows: "The same observations are applicable to the composition of coal-gas. The gases discharged into the air, whether by the flame of a burner known as the bat's-wing, or by the smoky flame of one of Bunsen's burners, contains a notable portion of acetylene." How does that agree with your experience? A. I have perceived the odor from the smoky column of Bunsen's burners, but I have not perceived it from any ordinary gas-burner used for illuminating purposes, when not improperly used.

Q. If these statements are correct, would you not object to gas as served, on the ground that it contained acetylene? A. No; I see no reason for objecting. My wife does not object to the tea-kettle apparatus on that account.

Q. Is it not probable that the presence of carbonic acid in the gas might interfere with its complete combustion, and conduce to the formation of acetylene and carbonic oxide and similar offensive or poisonous products? A. Yes, if present in sufficient quantity.

Q. I will ask whether the emanations from the spent lime are injurious to the health of the community in which they are evolved? A. I think they are, because they nauseate.

Q. Is every thing which nauseates injurious to the health? A. I think it is, unless a person desires to be nauseated for some other difficulties.

Q. And every thing that is nauseating is a nuisance? A. Yes, unless it is resorted to to produce a nausea for a specific object.

Q. Do you mean to say that you have been nauseated by the atmosphere of the purifying-house of the Metropolitan Gas Company, for example? A. Well, I am not enough of a medical man to say what nauseating is; but I have been highly disgusted by the smell, and that is what I have understood medical men to understand by the word nauseating. I have not actually been made sick at my stomach, but I have had those impressions which are preliminary to that feeling.

Q. Did you ever know any person that was nauseated—any chemist, by breathing in the laboratory the sulphide of ammonium? A. Nauseated in the sense which I understand it there, I have; the effect that a highly disagreeable odor has upon a person.

Q. Do you mean that these odors which escape from the spent lime are any thing more than that you have said was disgusting to you—do you mean that? A. I mean that they are highly disgusting, and what people call nauseating. I am not a physician, and do not pretend to be an expert in medical terms.

Q. You do not mean to say they are detrimental to health? A. I do, because I think it is detrimental to health to be constantly nauseated.

Q. You do not think that there is any thing poisonous? A. Any thing that produces that disagreeable effect is called a poison, and it is a poison.

Q. Have they the ability to create a disease as a poison does? A. The term poison is so indefinite, I should prefer to say I consider them injurious to health.

Q. Now I beg you to state why they are injurious to health, in your own language. A. Because they nauseate in the sense I have used the term.

Q. In no other sense? A. Not to my knowledge.

Q. Have they no fermenting properties? A. No.

Q. Most poisons have, have they not? A. No.

Q. How is the odor of roses to you; agreeable or disagreeable? A. In a moderate quantity it is agreeable, though not my pet perfume.

Q. You know that persons are made sick by the smell of roses, even in small quantities? A. Yes.

Q. The same way with regard to the smell of strawberries? A. Yes.

Q. Makes a good many people sick, does it not? A. Yes.

Q. And to others it is delicious? A. So I have understood.

Q. There is no doubt about that? A. I think not.

Q. You would not ask to have them suppressed because they are disagreeable? A. That is so rare.

Q. Have you not heard that there are whole peoples to whom the smell of roses is disgusting and oppressive? A. Never heard of it.

Q. In Italy, for example? A. Never heard of it.

Q. Do you compare these exhalations from the spent lime-purifiers with exhalations which are known to be poisonous in minute qualities—like miasmatic exhalations, or those from putrid organic matters? How is that, doctor? A. I do not compare them with those exhalations which are supposed to be organized, and develop specific diseases.

Q. Are not the latter believed to be of the nature of ferments or organized germs capable of reproduction? A. They are by many persons.

Q. Is mere foulness of odor indicative of poison? A. Poison is an indefinite term.

Q. Is mere foulness of odor, then, indicative of poisonous qualities, or as positively injurious to health? A. I think it is so.

Q. Which? A. I think foul odors are, as you say, injurious to health.

Q. As I understand you, you do not compare these exhalations from the lime-purifiers with the exhalations known to be poisonous, like miasmatic exhalations, etc.; you do not class them in the same category? A. No, sir.

Q. Will you please to state with what known substances or injurious properties you do compare them in giving them the character you have, which are injurious in excessively minute quantities? A. I compare them with sulphide of ammonium and sulphuretted hydrogen.

Q. I understand you to say that you never knew in your experience, or heard of any persons, who had been killed by breathing one or the other; or that they had ever incurred any disease by breathing it? A. I made that statement.

Q. Do you consider the British Association of Gas Managers a body qualified to consider the subject of the purification of gas? A. Undoubtedly.

Q. In the inaugural address of the president of that body, Thomas Hawksley, Esq., on the 11th June, 1867. Have you seen it, doctor? A. No.

Q. The president says, in that address, in speaking of purification, as follows:

"If there be one thing more injurious than another to the persons by whom gas is consumed, it is the presence of sulphur in any amount in the gas, at the place where it is employed." What do you think about that statement of President Hawksley's? A. I do not think President Hawksley is any more competent to judge upon that point than myself.

Q. He regards the presence of sulphur in any amount as injurious. Do you agree with him? A. I do not agree with that, unless he means the presence of a large quantity. If he means the presence of any sulphur, I disagree with him; if of a large quantity, then I agree with him.

Q. I will read to you from this same address of President Hawksley, as follows:

"I think we shall all be agreed in the desirableness of adopting some means, if such means can be discovered, for the removal of this noxious material. Permit me, then, to mention to you merely as a subject for your consideration—for you all know a great deal about it—that the use of oxide of iron, which is in itself a very valuable material for the ordinary purification of gas from sulphuretted hydrogen, is insufficient, and a great deal of the obloquy which has fallen upon gas companies during the last few years has arisen from the adoption of that material, in substitution for the old mode of purification. We all know that lime is very liable to, and in all ordinary cases does, give off an obnoxious smell in the neighborhood; but it, undoubtedly, has this property that, if it creates a smell by reason of its being kept on the gas-works, it prevents a much more serious smell in the houses of the consumers, for what you fail to take out of the gas by the oxide of iron in substitution for the lime, really goes into the dwelling-houses, and manufactories, and shops of the consumers, in the form in which I exhibit, combined of course with the gas, but still, in every thousand cubic feet of gas there is a large quantity of sulphur to be burned in the interior of the building where the

gas is distributed. Under these circumstances, great attention has been paid to the elucidation of a better chemistry on this subject, and it has been ascertained by Dr. Letheby, as the result of a great number of experiments, made upon a very large scale, a considerable portion of which were conducted in the town—that whereas by the use of oxide of iron, you cannot remove the whole of the sulphur, but must leave in the gas from 20 to 25 grains in every 100 cubic feet, yet, by the use of lime alone, you may reduce that quantity down to less than one-half; in fact you may reduce it down to from 10 to 12 grains."

Now, Dr. Chandler, the question about these extracts is, whether you agree with the president in these statements? A. There are so many statements there—while I agree with some, I do not agree with others.

Q. State what you agree with, and what you do not agree with? A. I agree to the probable effect of lime in removing more sulphur than is removed by the oxide of iron, but on the other hand, I consider what is said about the effect of these few grains of sulphur, more or less in the gas, to be highly ridiculous and absurd; and am supported in this by the opinion of prominent chemists.

Q. Does that sulphur have the effect to nauseate? A. Not in the maximum quantity which occurs in the gas; it will not have the effect to nauseate.

Q. Do you not know that the British Parliament have passed an act in which it was provided that the gas delivered shall be freed from these small quantities? A. They have passed such an act; and they have passed a great many other ridiculous acts—the "Stamp Act," and several others.

Q. Then you regard the act of the British Parliament as a sanitary measure, in the same light that you do the act of the British Parliament imposing "stamp duties?" A. I do not say it. I say it does not follow that, because the British Parliament fixes it at 20 grains, that it was necessarily the proper limit. I know that the reason that led them to fix it at that point was insufficient.

Q. You say that, notwithstanding all that you have said, the lime process of purification is the process which is in use in all the large cities of the United States? A. Yes.

Q. Including the city of Philadelphia, the gas for which is manufactured and purified by the municipal corporation itself? A. Yes.

Q. Where does the purification of gas by the iron process prevail? A. In all the large cities of Europe.

Q. Are you not aware that, in communities where this process of purification by iron has been adopted, it has proved to be a failure, and that the companies that have adopted it, are, in many instances, abandoning it, and are returning to the lime process of purification. Have you not been so advised? A. I have been advised that the iron process is still in use on the Continent of Europe; but that, owing to this foolish law of the British Parliament, the gas companies have been so hampered—the iron process not allowing them to keep within the act—I have heard that, on that account, they would return to the lime process.

Q. As a process which would enable them to deliver gas of the purity required by the act of the British Parliament? A. Yes.

Q. And will you not say as an expert, that the lime process does deliver a purer gas to the consumer than the process of the oxide of iron? A. I think it does.

Redirect examination of Prof. Chandler was deferred.

TESTIMONY OF PROFESSOR BENJAMIN SILLIMAN, OF YALE COLLEGE.

Professor Benjamin Silliman, Jr., called for the Metropolitan Gas-Light Company, being duly sworn, testified as follows:

By Judge Van Voorst.—Q. State, if you please, your profession. A. I am a chemist, residing at New Haven, and have charge of the department of general and applied chemistry in the Academical Department of Yale College. I have been connected with the institution since 1847, as a professor, and since 1838, as a teacher.

Q. Have you given particular attention to the subject of the manufacture of coal-gas? A. I have been practically familiar with the manufacture of coal-gas for about twenty years.

Q. Have you studied the subject of its purification? A. I have.

Q. And have observed it practically? A. I have observed it practically.

Q. What is the method of purification of gas in use in the United States, as far as your knowledge and experience goes in that subject? A. The usual method of purification of gas in the United States is what is familiarly known as the dry-lime process, in which the hydrate of lime is employed; and there is in use in a few companies what is known usually as the wet process, in which the gas is first passed through a salt of iron, green vitriol, and then through milk of lime under pressure, under weight of machinery. I might further answer your question by saying that, so far as I know, there is but one company in the United States that employs the iron process, which is the usual process in Great Britain and on the Continent of Europe.

Q. What is the company you speak of? A. I think it is called the New York Gas-Light Company. It is the old company. I visited their works last summer.

Q. You have visited the Philadelphia companies' works? A. I have visited the Philadelphia companies several times.

Q. You have witnessed their processes? A. Yes, sir. I have been familiar with several gas-works, particularly Boston, Worcester, Hartford, New Haven, and Louisville.

Q. Have you been in Prof. Smith's establishment at Louisville? A. I have, recently.

Q. Since his return from the World's Fair? A. It was about the first or second week in September I was there. He uses the dry-lime process.

Q. You have witnessed the purification at the New York works. What, in your opinion, is the best mode of purification of gas? A. I have no hesitation in saying that, if it is properly conducted, the dry-lime process offers by far the best means of purification.

Q. Why? A. For several reasons: first, because it does effectually remove all the sulphur which is in a state of chemical combination, such as is capable of being removed on a large scale by any known process. I might make an exception of Dr. Bowditch's method. I know nothing about his method practically. I except, of course, in this generalization, the sulphur combined in such forms as to escape the ordinary tests employed to indicate its presence. Second, this process does effectually remove the carbonic acid, which no other known process does remove.

Q. Any other reason, professor? A. I do not think of any other. As regards ammonia, I do not know that it is more efficacious than other processes, and believe it is less efficacious than the process of wet lime with the salt of iron, which does remove all the ammonia.

Q. The most deleterious substance or element to which your attention is directed in purifying the gas—does it not seem to be sulphur? A. Yes, sir. In its various forms of combinations, it is the black beast of the coal-gas manufacturer.

Q. And which you seek to eliminate? A. And which we seek to eliminate. You will observe I made an important distinction. I said if applied with suitable precaution.

Q. It more effectually removes the sulphur? A. More effectually removes the sulphur than any other available process.

Q. What objection, if any, exists to the dry-lime process? A. The objections to the dry-lime process are twofold: first, that the material is exhausted, and to a great extent lost, in respect to its value in the act of purification, and that no process has yet been discovered by which it can be restored to a condition to purify gas again. That is a loss which falls upon the company.

Q. Any thing else? A. Second, that this accumulation, as an effete waste product about the gas-works, as ordinarily conducted, constitutes a just ground of complaint as a nuisance, using the term nuisance in the sense of that which is offensive.

Q. Offensive to the smell? A. Yes, sir. I classify nuisances under two general heads—those which are offensive to the sense of smell, and as such repulsive to our sense of taste; others which are deleterious and noxious as regards health. In the first class I would arrange gas-works and stables among causes of that kind; and in the second I would place all such nuisances as bone-boiling establishments and glue establishments, and others where putrescent animal matter is the subject of treatment; which are decidedly and confessedly injurious to public health.

Q. You do not consider the emanations from the gas-works of which you have spoken, as deleterious to health? A. Long familiarity with the management of the New Haven Company, with which I have been associated as a director, has satisfied me that no injury to

health—no bodily injury—attaches to the use of dry lime. By diligent inquiries, the only complaint I have heard was, some irritation of the eyes of the persons about the boxes, when they are opened. That proceeds from the ammonia and is entirely transitory. On the contrary, parties living in the immediate vicinity of these works have always asserted that they have enjoyed excellent health.

Q. Then you do not regard those exhalations or emanations as deleterious to health? A. I do not. I should like to distinguish, however, between the classes of emanations which are given off in the decomposition of effete lime. I would call your attention to what seems to me an important distinction that exists between two quite distinct groups of exhalations, viz.: that the first effect of the atmospheric air upon the effete mass is an effect of oxidation, resulting in a state of high temperature, the whole mass of the effete lime becoming so hot that you cannot conveniently bear your hand in it, and this process of oxidation accompanied by the production of watery vapor and free ammonia, which exercises a stimulant effect, such as is due to this active agent; and, second, an entirely distinct class of effects is that which arises from the gradual separation, at a later stage of the process, of highly-offensive hydrocarbons, probably containing sulphur as one of their constituents, and characterized by an extremely persistent odor. This latter class of odors I have observed is not developed in the earlier stages of the decomposition of the mass. There is always to be perceived during the process of oxidation, as alluded to, the odor of sulphuretted hydrogen escaping from the decomposition or combustion of the sulphide of ammonium; but this odor of sulphuretted hydrogen or sulphide of ammonium, is restricted to a radius of limited extent—measuring from the purifying-box as a starting-point—and soon disappears. I have here some samples of lead-paper, which illustrate this remark. There, sir, is a sample of lead-paper, prepared this morning, in the yard of the Metropolitan Gas Company, by exposing the paper, when moist, to the atmosphere of the yard, at a measured distance of forty feet from the building, and in close proximity to one of the telescopic holders of the yard. Here is another lead-paper, prepared in precisely the same manner, which was exposed at a distance of sixty feet from the windows of the purifying-houses, the wind blowing from the direction of the house strong over the paper. Here is another paper of precisely the same kind, which was exposed at the measured distance of seventy feet from the same point. All these measurements were taken from the same point; and here is a fourth, at a distance of seventy-five feet northeast. I think you will perceive distinctly a diminution of the intensity of the action of these sulphur compounds with this moderate increase of distance. The last is very slight—scarcely perceptible.

Q. At a distance of seventy-five feet from the works, the wind blowing from the purifying-house, it scarcely discolored? A. It scarcely discolored the lead-papers. I should remark that these lead-papers were all exposed in a moist state, and remained there exposed until they had dried off in the wind, which was about fifteen or twenty minutes.

Q. You mean that the sulphide of ammonium evolved from the lime was so diffused at that distance that it made a very slight impression upon the paper? A. Yes, sir. Another very characteristic odor of the effete lime—spent lime—is that which is attributable to naphthaline—a substance which is always found to a greater or less extent in connection with spent lime, and which develops itself frequently in the latter stages of the decomposition—some weeks even after the material has been exposed to the action of the air. This beautiful pearly and micaceous substance appears in brilliant crystalline plates, lining the cavities or covering the surface upon the spent lime, and its odor is, likewise, clearly perceived at an early stage, when the box is first opened. The odor of naphthaline is agreeable to me. It is employed in small quantities as a perfume. I will exhibit some samples I picked out of a heap this morning from the pile of spent lime which had been exposed some three weeks. You will see that it is perfectly filled with those beautiful scales of naphthaline.

Q. You were there at the Metropolitan Works when the purifiers were opened? A. I was

Q. This morning? A. Yes, sir. They had one opened specially for our inspection, and which had been running, I was informed, forty-one hours prior to the time when we saw it opened; and that there had passed in that time, by the registration of the station meter, one million feet of gas.

Q. What was the state of the atmosphere there this morning, when you were there? A.

The outer atmosphere was bright, and clear, and cold. The atmosphere of the room, before the box was opened, was not disagreeable; and, when it was opened, there was an odor of naphthaline, and, for some little time, I could perceive nothing else. Very soon, however, the powerful action of oxidation set in, and the lime began to give off vapor of rather a strong odor of ammonia, overpowering every thing else.

Q. Is ammonia deleterious to health? A. It is estimated the reverse.

Q. It is a stimulant? A. Yes, sir. Administered to revive fainting persons.

Q. Was there any sulphide of ammonium present? A. Undoubtedly.

Q. How much? A. It is impossible to form any more than an empirical judgment as to that. The nose is a poor analyst. Undoubtedly there is a large quantity of sulphide of ammonium.

Q. In this connection, now, I will ask you, what are the objections to the iron process of purification? A. The principal objection as I conceive to the iron process, is, that it is less efficacious, in general, as a means of purification than lime. It does not so efficaciously remove the free sulphur. It does not effectually remove the carbonic acid. It does not effectually remove the ammonia.

Q. It does not effectually remove the phenol? A. That I cannot speak of from my personal knowledge.

Q. State the objections to the process? A. There is this principal objection: I conceive that in every Metropolitan Gas Works it is the bounden duty of the company to exercise all possible dilligence to avoid the nuisances which are sure to manifest themselves, whatever agents may be employed for purifying; and, for this purpose, there is no means hitherto discovered that appears to be so efficacious as the method of ventilation, which has been recently adopted by the Manhattan Works in this town, and this process of ventilation appears to be inapplicable to the iron process for the important reason, as it appears from the writings of Mr. Clegg and other English authorities, that the heat generated by the active chemical efficiency of the oxygen is created in such an amount as to heat the mass to redness and set fire to the wooden screens and destroy the apparatus; while, in the case of spent lime, ventilation restores it to a condition inoffensive to health, and leaving a product which, as I conceive, has high value for agricultural purposes. I shall present a specimen of spent lime which I took from one of the boxes of the Manhattan Works, which represents fairly the mass of the material as it exists in the boxes. There is a feeble odor slightly of ammonia and slightly of gas-tar, but it is not an offensive material. I speak of it in a large way. It consists chiefly of sulphate and sulphite of lime, with some free lime, called hydrate of lime, and carbonate of lime; and is, therefore, a mixture which the agriculturists may employ with great advantage as a fertilizer, which is not true of the spent lime—of the dry-lime process, as it is ordinarily sold by gas companies for such uses.

Q. What odors does the effete iron give forth after it has purified the gas? A. My recollections of the visit which I paid to the New York Company, last June or July, are not very distinct; but my recollections are that the mass smelt of ammonia, and that there was, also, to some extent, the usual familiar odor of the gas-house, but decidedly to a less extent than in case of the lime purification.

Q. Were they nauseating or disgusting in their character—did they have that tendency? A. I could not say that they had; at the same time I ought to state, in that connection, that my attention was not so much directed to any question of the sanitary effect as to the economic one as affected by the iron process in place of the lime process. I went there expressly as a director of the New Haven Company—in that point of view.

Q. You concluded not to adopt it? A. Concluded not to adopt it. I was not satisfied with the degree of purification of the gas.

Q. Do I understand you to say that the oxide of iron fails to eliminate the sulphur in the various forms in which it exists in the gas? A. Not in so broad terms. I say that it fails to eliminate it to the same extent as lime does.

Q. Have you observed, since you have been in New York, the gas delivered by the Metropolitan Gas Company? A. I have this morning, and measured it with the photometer. I also tested it with lead-paper to determine the presence or absence of free sulphur compounds, and found none.

Q. Is there not, as yet, much obscurity in the minds of chemists generally, about the complete nature of the action of the lime—the complete composition of the waste and the effluvia therefrom? A. I do not know of any thorough chemical research upon the whole subject of purification of gas; and certainly think there are many important questions connected therewith that need further examination.

Q. In a sanitary point of view, do you think the purification by the oxide of iron has any advantages over the lime process of purification? A. Not if the lime process is conducted with suitable precaution; on the contrary, I conceive that, in the aggregate, the annoyance and injury to property which results from impure gas—

Q. I am speaking in a sanitary point of view. A. It affects the health. The respiration of air in a close room affects the eyes and the organs of respiration by reason of the presence of sulphurous acid, or sulphate of ammonia, or both, which may be present, which are given out in the process of combustion, and which ought to be removed, in great measure, in the purifying-house.

Q. In a sanitary point of view, comparing these two processes of the purification, and the quality of gas delivered by them respectively, do you not give the preference to the lime process of purification over that of oxide of iron? A. With the same explanation as before —that the lime process, conducted in a proper manner, I think, is capable of producing the best results for the public good.

Q. State, if you please, what is your own personal experience in regard to the burning of gas charged with sulphur, in a close room? A. I have often observed that, upon placing my head in an elevated position, as upon a step-ladder, or any other means of reaching the upper portion of the room where numerous gas-lights were burning, there was a very decided irritation to the organs of respiration, and to the eyes; and resulting as I conceive (and know in fact) from the production of ammoniacal salts, and of sulphurous acid. I find ammonia to be a much more frequently-occurring impurity in gas than most writers report.

Q. Is not sulphide of ammonium a very unstable, perishable, and transient substance in the air? A. I have reason to suppose that sulphide of ammonium is rapidly oxidized by the action of the atmosphere with the production of free sulphur and water, of course.

Q. Is not sulphuretted hydrogen quickly destroyed by the air? A. It is. I have observed that, in visiting the natural sources of sulphuretted hydrogen, such as the famous baths in the neighborhood of Rome, and other lakes and springs, the odor of sulphuretted hydrogen does not penetrate, nor is it carried to any great distance from the springs.

Q. Is there any sulphuretted hydrogen concerned in this case at all? A. No, sir; I cannot conceive of the existence of sulphuretted hydrogen, as such, in a free state, in presence of an atmosphere so highly charged with free ammonia as we find that to be where a dry-lime purifier is freshly opened, and the process of atmospheric oxidation has set in. I might add in that connection the sulphur compound which affects the lead-paper I conceive to be, generally, if not exclusively, sulphide of ammonium. This lead-paper is the only guide which the gas-maker employs to determine when the gas is sufficiently purified to be sent to the consumer, purified from the sulphur, of course.

Q. Did you ever know or hear of an employee or visitor in any gas-works being killed by the effluvia of the fouled purifiers, or injured thereby? A. Never.

Q. What is the state of health of those persons who are concerned in and about your purifying-house, in the New Haven Works, and other places? A. I think I have answered that question. I should say in general that I have always made diligent inquiries wherever I have been about the health of the persons employed about the purifying-houses, and the answer has always been that their health was excellent.

Q. You do not know that they are subject to any particular diseases? A. No, sir; there is a prevalent opinion, which may be worthy of record, that, in times of epidemic disease, such as cholera and yellow fever, they do not prevail in the vicinity of gas-houses. I heard that opinion expressed very confidently in New Orleans twenty years ago, where the yellow fever is very prevalent.

Q. What do you attribute that to? A. I conceive it must be attributable to the specific medical effect of some of the products of the distillation of coal, of which I would name car-

bolic acid, which is the same thing as phenol, as the most perfect representative of that class of agents which are most destructive to the spores and germs of fermentation of fungoid growth to which some physicians, with some confidence, attribute epidemic diseases.

Q. Has the presence of sulphur any thing to do with it? A. Sulphurous acid is well known to act in the same manner as an efficient agent in the destruction of germs and spores which produce ferment and disease; and sulphur itself, as such, is largely employed for the destruction of mildew. I do not know that sulphur or sulphurous acid, either, in this case of gas-works, has any application.

Q. Are the emanations or exhalations from the spent lime, when the purifiers are opened, poisonous or deleterious to health? A. I should say, decidedly not deleterious to health—that would open the question of what you mean by poison.

Q. Deleterious to health? A. I think a man would speedily be killed in an atmosphere of pure ammonia.

Q. Whether the process of manufacture of gas by the Metropolitan Gas Company, as you have observed it, gives forth any deleterious gas or odor detrimental to health? A. No.

Q. How would you compare those exhalations or emanations from organic substances which produce those disagreeable odors which you speak of as from bone-boiling houses? A. I can say that, in all cases where putrescent animal matters are undergoing transformation, there are emanations which may be, and in many cases probably are, decidedly detrimental to public health. It is well known that those emanations excite putrescence in other substances, causing milk to pass rapidly into acetous and putrefactive fermentations. I have no doubt that a carcass, as of a sheep, hung up in the purifying-house of a gas-works, would escape putrefaction very much longer than when hung within a short distance of one of those sources of animal contamination, or even a tenement-house. It is well known to chemists that animal substances are prevented from passing into a state of decay by being simply exposed to gaseous exhalations of gas possessing antiseptic properties, such as sulphurous acid and phenol, and carbonic oxide. It is well known that meats or dead bodies washed with phenol escape for a long time the action of putrescence, and for the same reason coal-tar is an antiseptic, because it contains several of these substances.

Q. I ask you this: whether you observed, in the neighborhood of the Metropolitan Gas-Works, any causes which would be likely to produce these contaminating or deleterious odors of which you speak? A. When I went down Forty-second Street this morning, before I reached the works, the wind blowing strong from the water toward me, I perceived very decidedly the odor of decomposed animal matter. The familiar odor of bone-boiling or fat-houses, or piggeries, or all combined. I did not know what source it came from, but I called the attention of my companions to the fact that there was a stench which many persons in their ignorance might attribute to the gas-house, which was not far off, but I was very particular to remark that it was clearly attributable to some cause to me unknown, like the house or manufactory alluded to. I was informed that there were, in that direction, below me, places of that kind—I believe a piggery or bone-boiling place, but I did not visit them.

Q. How soon after reaching Forty-second Street did you notice these odors? A. After I left Tenth Avenue, I noticed it before we had passed one hundred feet. It evidently proceeded from the direction of the wind, which was blowing out of the southwest at that time.

Q. And had its origin in decomposing or decomposed animal substances? A. It so addressed itself to my senses.

Q. And it had none of the properties peculiar to gas or its manufacture? A. None whatever.

Q. And those you would say were of a character detrimental to health. A. Such I conceive to be detrimental to health.

Adjourned to Saturday, February 13th, at 10 o'clock.

CONTINUATION OF THE HEARING BEFORE S. C. HAWLEY.

Professor Benjamin Silliman, recalled. Examination resumed by Judge *Van Vorst:*

Q. Professor Silliman, you spoke about having visited the Gas-Works in Boston, Phila-

delphia, and in some other places—state, if you please, in what part of the city those gas-works are located, as to their being surrounded by population? A. The densely-peopled part of the old town of Boston is the location of the gas-works there.

Q. How in the other places? A. The Northern Liberties Works in Philadelphia, which is an independent corporation not owned by the city, is also in a densely-settled portion of the town; there are, at present, I believe, three distinct gas-works in Philadelphia, not under the management of the corporation; I have not visited all of these; but one of them, certainly, is in a thickly-settled portion of the city. The Manhattan Works, as every one knows, is in a very densely-settled part of the town; so are the old works of the New York City Company.

Q. You mentioned that, in the gas delivered by the oxide-of-iron process of purification, there was remaining the element of sulphur, the same having been imperfectly extracted? A. I stated that the iron process failed to remove sulphur to the same complete extent to which the dry-lime process removed it; but there is some remaining—a portion of what is not called the free sulphur—which would not have been there, if the other process had been adopted; that, I beg to say, is entirely independent of any chemical combination in the gas which makes its appearance only when the gas is burned.

Q. That is not developed until combustion takes place? A. No, sir. The other is that which is in a state of such chemical combination, that it gives to the gas manufactured an ocular evidence of its presence by staining the lead-paper.

Q. Can that be discovered by testing it with lead-paper in a dwelling-house as it comes from the pipes? A. If the gas is imperfectly purified.

Q. What, if any other defects, are there incidental to the oxide-of-iron process of purification—state them if you please? A. I can conceive a greater objection to the iron process than the small residue of sulphur which is left: it is to be found in the carbonic acid, which the iron fails to remove from the gas. It is well known to all who are familiar with gas, that the presence of this small proportion of carbonic acid greatly reduces the illuminating power of the gas; and that it also, in a corresponding degree, diminishes the temperature of its combustion; I consider this a great defect, for two reasons: that, in the first place, it is the bounden duty of all gas companies to render to the community the best possible illuminator, and they fail in their duty when they fail to do this; second, the presence of the carbonic acid, alluded to, involves another danger, namely: the imperfect combustion of the gas, with more or less acetylene and carbonic oxide, or oxide of carbon; the carbonic oxide is one of the most poisonous of gases—far more so, one hundred times more so, Dumas says, than carbonic acid, which is commonly reputed a poisonous gas.

Q. Where the oxide of iron fails as a purifier, in this regard, the lime process succeeds? A. The lime process is perfectly successful in the removal of the whole of the carbonic acid; and, if it fails to do so in any case, it is simply from a slovenly application of the method; I can conceive that this feature of the iron process is its essentially weak point.

Q. Would you, as an expert, and chemist, advise the Metropolitan Gas-Light Company to do away with the lime process of purification, and adopt, in preference to it, the oxide-of-iron purification, for any reasons? A. I could not say; I should like to add a qualification to that: provided, the Metropolitan Company take all needful and proper precautions to avoid the just causes of offence and complaint which exist against the lime process, when not carefully conducted.

Q. You have ventured that modification in your answer, and I, therefore, will ask the question of you: what improvements could you suggest to the Metropolitan Gas-Light Company, in the way of the manufacture and purification of gas? A. Granting that the surface area of their lime-purifiers is adequate to their daily production of gas—which is a point about which I am not fully satisfied—the one important thing needful for them to do, to avoid all just causes of complaint, is, in my judgment, that they should adopt a system of ventilation by atmospheric air, drawn by an exhauster through a box containing the spent lime after its cover has been raised, so that the atmosphere may have access, and before the process of oxidation—previously described at our last session—has set in, and the conveyance of the contaminated atmosphere drawn by the exhauster to another set of lime-boxes charged with

ventilated lime, which lime has been found, by a frequent experiment—a constant daily experiment at the Manhattan Works—adequate to the complete absorption of all the offensive odors which are, otherwise, exhaled into the atmosphere. This process, properly conducted, leaves the lime in the exhausted box, in a condition of sulphate, or sulphite of lime and carbonate of lime—with a portion of unexhausted hydrate of lime, which is always present to a noticeable extent; this mixture is completely inoffensive; and may be left exposed to the atmosphere, without annoyance to any one, and constitutes a valuable fertilizer which may be safely applied at once, in the business of agriculture; whereas, as is well known, the ordinary spent lime of gas-works requires a long process of exposure, in order that it may not be rather injurious than beneficial to the farmer.

Q. What is the quality of coal that the Metropolitan Gas-Light Company uses in the manufacture of gas? A. I made particular inquiry last week, when at the works, with reference to this matter, and I found in their sheds the best qualities of bituminous coals. They were using, at that time, as their stock-coal, the Westmoreland, of Pennsylvania, which the best manufacturers of gas are pretty well agreed is one of the best coals accessible to the Atlantic border. They use, also, the Boghead cannel, which is universally esteemed as the richest of all the enriching coals. They had, also, the Lesmabago cannel, which stands next in commercial value and in illuminating power, to the Boghead. They had, also, several other of the more esteemed varieties of the European cannel coals, but, as I understand from Mr. White, the chief engineer, they were depending chiefly, for the enriching of the quality of the gas, upon a mixture of Lesmabago and Boghead. I failed to mention by name one of the other coals which should be mentioned particularly, as it is in constant use there—the well-known Wigan cannel.

Q. What length of time would it take for the purpose of making those improvements that you suggest for the ventilation of lime? A. Those improvements would require the construction of another house to contain the oxidating boxes; and its construction, with the necessary underground works for the exhausters, I should think would require two or three months. That question, I should think, is one which would be better answered by the engineer of the company; for the conditions under which the work can be done may require that it be done in the summer—that is, it may not be possible to do it while the ground is frozen.

Q. Do you know B. Howard Rand, Professor of Chemistry in the Philadelphia College of Medicine, and lecturer upon chemistry in the Franklin Institute? A. Yes, sir—he is well known. I am not certain as to his being in that institution.

Q. What is his reputation as a writer and lecturer on chemistry? A. He is a good chemical authority.

Q. I have before me an answer of Mr. Rand's, in these words: "I do not believe that the odors arising from the refuse water and the other residuary products of gas manufacture are, or may be, injurious to health when the dry lime is used in the purifiers, and is then exposed to the air and light. Sulphuretted hydrogen or hydro-sulphuric acid gas is disengaged. When the well containing ammoniacal liquor is allowed to remain uncovered, ammonia and hydro-sulphate of ammonia are given off. That these gases, however, although offensive to most persons, cannot be considered as causes of disease, or injurious to health, when freely diluted, is shown by the fact that the men, engaged in removing night-soil as a nightly occupation, do not suffer in health, although exposed to these very gases in a far more concentrated condition than they can exist from the causes already named, and mixed with organic emanations of an equally offensive nature, which would certainly aid the injurious effect of these gases, did any such exist." Do you agree with Professor Rand? A. I do in the main. I might not agree with the exact transformation he speaks of, but, in regard to the sanitary effect, I have expressed myself to that effect in the testimony given last week. I wish to say in this connection that I do not think the permitting of the escape of those effete products, in densely-peopled regions, is not a just cause of complaint as an offence against the nostrils of the community. This is quite another question.

Q. I am speaking of the matter as to their deleteriousness to health. A. I do not consider them deleterious to health—they may be annoying to comfort.

Q. As to the truthfulness of any charges which are made in regard to the emanations from the Metropolitan Gas Company, as being injurious to the health of the neighborhood—and especially to young persons and such—is there any foundation for such charges? A. I do not believe there is any just ground for any such charges.

Q. You have seen nothing to justify them? A. I have seen nothing to justify that allegation.

Cross-examined by Mr. Hastings, assistant-attorney for the Board of Health:

Q. You stated, in your direct examination, that you had been practically familiar with the manufacture and purification of gas for about twenty years, and had studied the subject of its purification, both theoretically and practically—please state what processes of purification you have studied practically. A. My practical experience with the purification of gas has been chiefly with the dry-lime, but I have also had some familiarity with the wet-lime purification, and I have inspected the iron process.

Q. Did you ever study Laming's process practically? A. No, sir; Laming's process has been brought into general use since I was in Europe, and I have not had an opportunity to examine it practically—meaning by that, studying it in the gas-works; I have been familiar with Laming's process as a student in the science of gas purification.

Q. Did you ever study the iron-ore process, as used in England, practically? A. No, not practically in the works.

Q. Have you a practical knowledge of any iron process? A. Not of my own experience.

Q. Then your practical knowledge is confined to the lime process? A. My practical experience—personal experience, as an administrator of gas-works; so far as I am advised, there is but one, possibly two works, in this country where the iron process is in use; one of these, and the most important, I have examined, but not, in the proper sense of the word, practically, as I have not abided there for the purpose of studying it, day by day, as I should do if I was in charge of the works.

Q. If not acquainted with the iron process, do you consider yourself fully competent to advise with regard to its use? A. I do; I do not conceive it is necessary for me to have spent months in the gas-works in order to reach a safe and trusty judgment; the processes involved in it are perfectly plain and obvious to any chemist; the objections which exist against it I have already stated, and they are such as must meet the assent of every chemist; they are inherent in the very nature of the process. It is a most excellent process up to a certain point, but it fails beyond that point. The English companies have been compelled by law into its adoption; but I know, from my reading and familiarity with gas engineers and gas literature, that they would gladly return to the lime process, if it were practicable for them to do so, in densely-peopled centres like London; but that there are practical difficulties attending the use of the lime process there, every gas engineer is perfectly free to admit practical difficulties growing out, especially, of getting rid of the waste. The iron process offers to the gas companies the important advantage of economy in the administration of their affairs, in that they have not the daily-recurring expense of purchasing new quantities of lime, and disposing of it, and, perhaps, at a loss; for, when they have once got their stock of iron on hand, it is revived by the oxygen of the air and the chemical transformation, as already explained; and the expense is therefore reduced to the manual labor of handling the material.

Q. This is an advantage to the companies, but it is not necessarily an advantage to the community. What are the practical difficulties in its use, that you refer to? A. Of the iron process?

Q. Yes, sir. A. I have already stated those in my direct testimony as being, especially, the failure of the iron process to remove the carbonic acid.

Q. Give us the outlines, if you please. A. That it fails to remove, as perfectly as lime does, the sulphur; and that, in leaving a considerable portion of the carbonic acid in the gas, it not only abases the illuminating power, but reduces the temperature of the combustion, involving the risk of production of carbonic acid and acetylene.

Q. As a general rule, does not a practical acquaintance with any process tend to correct or modify views you may have formed in advance of its adoption? A. I entered on the study of the iron question without the slightest prejudice in its favor or against it. It is, undoubt-

edly, true that a practical familiarity with any process may tend to remove objections which are not well founded, but it cannot remove objections which are real and inherent, and in the nature of things. Nothing can alter the properties of carbonic acid.

Q. Not having tested the iron process in its various combinations, are you able to state that the objections you name are well founded? A. On general principles, yes, sir. I agree perfectly that if the lime process is made supplementary to the iron process to such an extent as that the carbonic acid shall be absorbed by lime, then the good effects of the two processes may be combined; but that is attended by another and very serious objection of a practical nature, irrespective of expense, and that objection is, that the gas suffers a needless loss of its illuminating power. It is a perfectly well-accepted principle, among gas engineers, that over-purification is a fatal error in the manufacture of gas. It is perfectly well known to chemists who are familiar with this subject, that the illuminating power of gas lies within exceedingly narrow limits, and that the volatile hydro-carbons which are held in a gaseous state in an elastic form in gas, belonging to the olefiant-gas series, are very easily removed from gas by over-purification.

Q. In your statement, that over-purification is a fatal error, you restrict it to the illuminating properties of the gas? A. Yes, sir, certainly—the illuminating properties of the gas. It is very well agreed now, among gas engineers, that that error has consisted to a too great extent in the scrubbing of the gas with the water—that the prolonged contact of gas with water, in scrubbing, has had the effect to remove too much of the illuminating power; and the purification process has been seriously modified by the best gas-engineers, in the recent times, in the omission, to a certain extent, of the scrubbing.

Q. Does not the scrubbing process tend to remove the offensiveness of the gas? A. Undoubtedly, but it may be carried too far, as already indicated.

Q. Too far with reference to the illuminating power? A. Not merely that. It may be carried so far as to remove all the free ammonia, and, in that case, the gas has not present in it a trace of ammonia to combine with the sulphurous acid formed by the combustion of the sulphur compounds with the production of sulphite and sulphate of ammonia in place of sulphurous acid.

Q. When and where have you seen green vitriol used in connection with the milk of lime you refer to? A. I should like to suggest a modification of your question, because I did not state that it was connected with green vitriol, for that would be preposterous. I said the two things are used in succession.

Q. You did not mean to state that you have ever known green vitriol to be used in connection with milk of lime? A. Not in the same vessel. This process is in use in Boston, and has been there used, to my knowledge, for twenty-five years. Since I had the pleasure of meeting you last, I have had an interview with Mr. Greenough, President of the Boston Gas-Works, who informs me that they still employ the wet-lime process, which process involves, as an essential feature, the partial use of green vitriol—in a distinct vessel, of course. The same process is in use in Providence.

Q. The iron process? A. No, sir.

Q. The wet lime and green vitriol? A. Yes, sir.

Q. Is not that an iron process? A. No, sir, not in the sense that gas-engineers use it. In the one case you will use sesquioxide of iron, and in the other proto-oxide of iron. In the one case you remove the ammonia, in the other not.

Q. Then the gas-works in Boston and Providence do use a different process from that employed by the Metropolitan Gas Company? A. Yes, sir; I so stated in my direct testimony; I believe there are other works in New England that do the same, but those are the only ones I have a personal knowledge of.

Q. Where is the wet-lime process now used in the United States? A. The places I have just mentioned, I say of my own knowledge.

Q. What is the difference between Laming's process and the iron-ore process employed in Europe? A. In Laming's process there was a mixture of lime and sulphate of iron, with a view to the removal of the ammonia and carbonic acid. The iron-ore process, as it is employed on the Continent of Europe, I have never seen personally, but, as I understand from

those who have, it involves the use of the ore of iron—limonite—crushed and reduced to a proper state of powder, and mingled with some inert substance like saw-dust, spent tan bark, or some other inert substance.

Q. Can you state how Laming's mixture is made? A. I have never witnessed the preparation of Laming's mixture.

Q. What are the processes generally used in Great Britain or on the Continent? A. I think I have already stated in the direct examination that, in London and on the Continent of Europe, the usual process employed is the iron process; that is a point admitted fully, I think.

Q. Why has this process been employed instead of the lime process formerly in use? A. Chiefly from municipal regulations.

Q. What other reasons influence its employment? A. I think the cause which has been most influential, perhaps, with the companies, has been the consideration of economy, on their part. The restrictions in Great Britain, particularly with regard to the illuminating power, had been so very low, admitting the use of twelve or thirteen candle gas, that it did not signify if there was a certain quantity of carbonic acid left in the gas, inasmuch as I have already explained, in a former answer, the cost of the iron process is chiefly in the purchasing and maintenance of the stock, which is but very slowly exhausted and reduced, and is mainly due to the item of manual labor in the manipulation. There is an obvious economy on the part of the companies in their general expenses of administration, in the use of the iron process. They have not to purchase, daily, new quantities of lime, nor to haul away the refuse. It is objected with great force; by Mr. Clegg and others, to the use of the iron process, that its ventilation by the system known as Palmer's system is impracticable, because of the destruction of the apparatus, incidental to the high heat produced by the oxidation of the iron, which is sufficient even to raise the mass to redness.

Q. That objection would apply only to wooden apparatus? A. Yes, sir; I can conceive so; if the temperature rises to redness, it would undoubtedly endanger the purifying-boxes, and would agglutinate the material so as to require some more mechanical treatment than the shovelling to reduce it to a condition fit for use.

Q. Has not the question of offensiveness influenced the change from the lime process to the iron process? A. Unquestionably; that has been undoubtedly the principal or efficient cause that has induced legislation on the part of Parliament and municipal regulations, the offensiveness of the lime process. It is offensive—that is what we are all ready to admit.

Q. In your reference to municipal regulations, what may we understand you to mean? A. I understand that in Europe the police or local magistracy may present a gas company as a nuisance, if they judge, in their opinion, that the case is worthy of it; and that is what I mean by municipal regulations, as it is distinct from the general Metropolitan Gas Act, or Parliamentary Act under which the general administration of gas companies is placed.

Q. You would recognize, then, three distinct processes in present use—the dry lime, Laming's, and the iron process? A. I recognize four.

Q. The wet lime also, I suppose? A. The dry lime, wet lime, Laming's process, and the iron process. There are essentially two, however—the lime process and the iron process. The others are modifications.

Q. You stated as an objection to the dry-lime process, that the accumulation of the effete waste product about the gas-works, as ordinarily conducted, constitutes a just ground of complaint as a nuisance. Do you mean to limit this term nuisance to offensiveness of smell? A. I do; and I mean also to limit that remark to the lime which is of comparatively recent origin, because in the accumulations about a gas-works, where large masses of effete lime are piled up, it is only a comparatively small portion which is offensive. The same effect takes place in a few weeks by the natural process of atmospheric oxidation which, by ventilation, may be made to take place in two or three hours.

Q. Why, in large gas-works, would not this effete lime be exposed every few hours? The ventilators are opened about once a day, as I understand, in the winter season? A. I do not know that I understand what you mean by ventilators.

Q. The purifying-boxes, I should say? A. The purifying-boxes are opened at least once

in twenty-four hours, ordinarily, once in twenty-four to forty hours; but, when the purifying-boxes are opened for the purpose of ventilation, there is no offence, because the act of ventilation commences instantly with the opening, and a current of air is then drawn inward to the products, so as to conduct them toward the other lime-box where the offensive gases are secured.

Q. As a general rule, does not the introduction of any foreign element into the common atmosphere tend to taint and deteriorate it? A. That is a general question, is it?

Q. Yes, sir. A. Certainly.

Q. Will you state, in the order of their predominance, the constituents of the foul gas-lime? A. I don't know that I should be able to do so with accuracy from memory, as it is a pretty complex mixture; but I would mention the sulphide of calcium, and the sulphide of ammonium, and the carbonate of lime, and the unexhausted hydrate of lime. Various compounds containing cyanogen, naphthaline, sulphuretted hydrocarbons, gas-tar, probably phenol, or other analogous compounds, carbonic disulphide. This last product is commonly esteemed one of constant presence in the effete products of gas distillation, but, I have reason to believe that it is not so commonly present as is supposed, from my own experiments. This is a general statement of what I conceive to be the important constituents present in the effete lime, prior to oxidation, while the box is yet closed, before atmospheric oxidation sets in. This effects important atmospheric transformations not here considered.

Q. This carbonic disulphide is identical with bisulphide of carbon? A. Yes, sir.

Q. What gases are evolved from this mixture when exposed to the action of the air? A. The first effect of access of atmospheric air to this mixture is that of oxidation, accompanied by a considerable elevation of the temperature, and the transformation of the previously-existing compounds into new states.

Q. Watery vapor is exhaled in considerable quantity, carrying with it sulphide of ammonium and free ammonia vapor of naphthaline and the vapors of various other hydrocarbons? A. I have answered this question in my direct examination, perhaps with sufficient fullness; I called attention in my direct examination to the important fact as touching the question at issue in this suit, that the vapors or exhalations, or gases if you please, which are given off from the effete lime, vary in the different stages of the progress of the oxidation or transformation; that the first and overpowering impression which is made, in the incipiency of this act of oxidation, is that of ammoniacal vapors, whether free ammonia or sulphide of ammonium, completely abasing and overpowering all other impressions; that the naphthaline odor is also easily recognized, but that the peculiar disgusting, heavy, persistent odors, which give to the gas-lime its abominable smell, do not make their appearance until a later stage of the process; and that these odors are often more distinctly perceived at a little distance from the works—I would rather say at a considerable distance from the works—than near at hand, while on the other hand the ammoniacal odors, and the other odors connected with the ammonia, disappear at no very considerable distance; in evidence of this I called the attention of the Board, at the last interview, to some test-paper which which had been exposed to the action of the atmosphere in the yard of the Metropolitan Gas-Works, showing that the radius, measuring from the purifying-house, upon which perceptible effects of sulphur vapors could be detected, did not exceed one hundred feet when the wind was blowing strongly in the direction of the paper from the purifying-houses.

Q. Which, if any, of these gases are poisonous? A. What do you mean by poisonous? Oxygen is poisonous.

Q. In the broad sense; not necessarily fatal to human life, but poisonous in tendency. A. There is no gas which, taken alone, may not in the strict sense be esteemed a poison. An animal will die if immersed in pure oxygen, and quickly, if immersed in pure nitrogen, by suffocation, yet the two gases together constitute the beneficial atmosphere in which we live. An animal will die if immersed in ammonia vapor, or in vapor of water, or in carbonic acid, either by direct suffocation or by specific poisonous influence. If by your question you intend to imply that either of the gases given off by the effete lime is exhaled in quantities sufficient to act as a poison, I take exception to the theory implied by the question. Sulphide of ammonium is undoubtedly a poison, in that a small quantity of it comparatively will de

stroy life. The same is true of ammonia; the same is preëminently true of carbonic oxide. But these substances are often all present in the atmosphere, even of the purifying-house, in relatively very small proportions, and I appeal to the universal experience of the dry-lime process of purification everywhere within my knowledge and reading, for the absence of any evidence tending to show that any poisonous influence is exercised by these gases upon the health of persons frequenting those places and the places most exposed to them. I have yet to learn of the first instance of personal suffering, except in the single case mentioned last week, of the irritation of the eyes where persons were exposed to ammoniacal vapor, and that was entirely transitory.

Q. When exposed to the air, what becomes of ammonia? A. Free ammonia will speedily combine with carbonic acid in the atmosphere. Free carbonate of ammonia dissolves in the watery vapor of the atmosphere, and is diffused and lost—lost to the senses, I mean—nothing is lost in a chemical sense.

Q. What gas will be liberated by the action of the carbonic acid of the air on the sulphide of calcium, after the ammonia has escaped? A. I conceive, in the first place, that the carbonic acid of the atmosphere plays a very insignificant part in these chemical transformations. It is present only in four or five parts in 10,000 in the atmosphere. Undoubtedly the transformation which you ask about would result in the decomposition of the sulphide of calcium, with the formation of calcic carbonate, and the evolution of hydric sulphide.

Q. To what agent do you attribute the coloring of the lead test-paper you exposed to the air outside of the purifying-house? A. Sulphide of ammonium. I do not conceive it possible that hydric sulphide as such should exist in an atmosphere abounding in free ammonia. The two substances will combine to form ammonic sulphide.

Q. You regard Knapp's Technology as good authority? A. Up to the time of its publication, the publication in 1855, the second edition.

Q. In vol. i., part 2d, of the London edition of 1855, at page 610, he remarks as follows: "The mechanical retention of the ammonia is one of the chief causes of the intolerable stench which gas-lime evolves when exposed to the air. Sulphuret of calcium evolves sulphuretted hydrogen slowly when decomposed by the carbonic acid of the atmosphere; but, if ammonia be not present, part is composed of hyposulphite, which has no smell. In the latter case, however, carbonic acid is rapidly absorbed by the ammonia, and the neutral decomposition then ensues between the sulphuret of calcium and carbonate of ammonia, producing carbonate of lime and sulphide of ammonium, which escapes with its characteristic odor. So great is the nuisance produced by the effluvia from gas-lime, that numerous plans have been at different times suggested for its prevention." Do you agree with his views as there expressed? A. The passage in question rests, as I conceive, upon a false hypothesis, viz., that it is the carbonic acid of the atmosphere which is the efficient and primary cause of the decomposition and chemical transformation of the effete lime. I cannot conceive that this theory is consistent with facts. The immediate and rapid elevation of the temperature, which is perceived upon the exposure of the mass to the atmosphere, is to be accounted for, as I conceive, by no other hypothesis than that which is connected with the action of the atmospheric oxygen. It is an assertion which does not correspond with my own observation and long familiarity with gas-yards, that the peculiarly offensive smell of the gas-lime is chiefly connected with the evolution of the ammoniacal products. I assume that the salts present in the mass, which are chiefly active in the primary oxidation and the evolution of ammonia, are the sulphide of ammonium and the sulphide of calcium, which may, if you please, be considered as united in a double sulphuretted salt. It is perfectly rational chemistry to assume that these salts react with a given number of atoms of atmospheric oxygen, with the evolution of free ammonia and the production of sulphite of lime, for example, or hyposulphite of lime, both of which are inoffensive substances. I differ with great diffidence and hesitation from so high an authority as Knapp's Technology, but it is a matter of chemical opinion, and one chemist has as much right to his opinion in such matters as another.

Q. Do you regard Samuel Clegg as a competent gas authority? A. I do. He is one of the standard authors. The chemistry of Clegg's book is attributed to Dr. Frankland, who is certainly one of the best chemical authorities in gas matters.

Q. In his work on the manufacture of coal-gas, fifth London edition, at page 187, he says "Foul lime as it is removed from the purifier consists of an admixture of several salts. Those only that need to be practically considered are the carbonate and hydro-sulphate of lime and the hydro-sulphate of ammonia, which constitute an important part of the total bulk. The analysis of these principal compounds shows that more than one-half the mass consists of carbonate of lime, nearly one-quarter of hydro-sulphate of lime, about one-fifth is hydrate of lime unacted on, and the residue contains the cyanogen salts and the silicious and other impurities of the limestone with the variable proportion of hydro-sulphate of ammonia retained in the mass mechanically. With such a mixture it is not surprising that the offensive odor is emitted on exposure to the atmosphere; for, in the first place, the hydro-sulphate of ammonia must pass into the air by a simple process of diffusion, while the hydro-sulphate of lime, being acted on by the carbonic acid of the atmosphere, will give rise to the formation of carbonate of lime, and a copious evolution of sulphuretted hydrogen gas. It is to the prevention of this evolution of sulphuretted hydrogen that the process of purification by oxide of iron owes its chief recommendation; for the affinity of oxide of iron for sulphuretted hydrogen is greater than for carbonic acid. Hence the sulphuret of iron, when removed from the purifiers and exposed to the air, emits no odor; while the sulphuret of lime is readily decomposed, and produces an abominable smell." To what extent, if any, do you differ from those views? A. I am perfectly familiar with the passage which is quoted. Have often read it. Some of its positions I accept, but in answer to the question would refer to the answer which has just been submitted to the next previous question. Inasmuch as I take a fundamentally different view of the nature of the chemical transformations, I consider the transformations due to atmospheric oxidation, and not to carbonic acid, and may be wrong in that opinion, but, having embraced and entertained that opinion, after mature consideration, I shall adhere to it until driven from it by experimental testimony. I have no partiality for one theory or hypothesis in this matter more than another, but seek to adopt that explanation of facts which is most rational and consists best with all the phenomena concerned. I don't mean to be understood as excluding by any means the action of carbonic acid in such action, but I do not consider it the primary and leading action; on the contrary, as already repeatedly expressed, that the action has its origin in the atmospheric oxygen. In support of this opinion I would submit the following chemical equations:

$N.H^4S$ +	CaS	+ O^4 =	NH^3,HO +	CaO,S^2O^2	
Sulphide of ammonium.	Sulphide of calcium.	Oxy-gen.	Ammonia.	Hyposulphite of lime.	

NH^4S +	CaS	+ O^7 =	NH^3,HO +	2(CaO,SO^2)
Sulphide of ammonium.	Sulph. of calc.	Oxy-gen.	Ammonia.	Sulphite of lime.

Q. Subject to these modifications, you assent to his views—do you not? A. Why, no, I consider the two views irreconcilable—they are fundamentally different—totally different hypotheses: one commences with carbonic acid, and the other commences with atmospheric oxygen and carbonic acid; in other words, you have not the same factors, and you cannot have the same products; and, therefore, the two views are irreconcilable.

Q. In Dingler, vol. cxxv., page 159, taken from Dr. Ure, in speaking of the general malaria of London in 1850, in reference to the injurious influence of the gas-lime on the health of the people, he says that, "in building up a part of London named Pimlico, gas-lime was used for filling up the swampy ground. During the month of October, 1849, five men descended into the sewer in Kenilworth Street, for repairing, where they suddenly died. The corpses had a bronze-blue color, especially on the mouth, neck, and heart. The sewer itself was 418 feet long, 4 feet high, and 2½ feet wide, and was constructed out of bricks. The southern end of this canal was shut up, on account of only three houses standing there; but the northern end communicated with other sewers. There could only be drain-waters entering the canal, as no other but those three houses had a communication with it. On the bottom of this sewer was found, on investigation, a greenish earthy material one foot in depth, covered with a similarly-colored stinking fluid. A similar mass was found outside on the top of the

canal. There was, therefore, no doubt but poisonous gases were generated from the gas-lime. Ure, and several other chemists, analyzed the solid as well as the fluid contents of this canal, with the following results:

"The solid mass was recognized as gas-lime saturated by hydro-sulphuric acid, sulphide of ammonium, and cyanogen compounds. In contact with the carbonic acid of the atmospheric air, those obnoxious gases were liberated and absorbed by the rain-water. This explains why the above-mentioned green-colored stinking fluid could contain those poisonous gases.

"From one of the London gas-works spent lime was taken and washed out with water; the fluid was then analyzed. One gallon of it contained 1,911 grains soluble matter, viz., 1,330 grains lime, 301 grains ammonia, and 280 grains sulphur. One gallon treated with hydrochloric acid generated nearly three (3) gallons of dangerous gases, and 3¼ gallons of this fluid yielded 1 ounce of Prussian blue, which represents 25 ounces of hydrocyanic acid of the strength required by the London Pharmacopœia, a quantity sufficient to kill fifty persons. By this one may judge how detrimental to the health of the neighborhood the accumulation of gas-lime must be." Do you consider the authority good? A. Ure is a good authority; I should infer from the reading of this evidence that these men had been killed by exhalations which undoubtedly had their origin in the gas-lime under these exceptional conditions, and which contained hydrocyanic acid or prussic acid. The evidence, as far as stated, corresponds with that mode of poisoning. I would remark in this connection that the sulphocyanide of ammonium is a well-recognized product of gas distillation; that it exists in all gas, probably; the illuminating gas I mean, as it is distributed to the houses; and it is the opinion of good gas chemists that it is the chief source of the sulphur which escapes in the combustion of the gas which has been otherwise purified from free sulphur. In this connection I would also say that the most thoroughly purified illuminating gas, it matters not by what method it may have been purified, is itself, in the sense which is here employed, a poison. An atmosphere containing a considerable portion of free illuminating gas would be destructive of health, and numerous cases are on record of life destroyed by persons who, having retired, have carelessly blown out their light instead of extinguishing it, and though the atmosphere could not, in the course of time intervening between the night and the morning, have contained more than ten per cent., at the outside, of its volume of these gases. The offensive odor which illuminating gas retains is to be regarded as a blessing and not as a curse, that it is the one sufficient warning to instruct an unscientific and incautious person of the existence of danger. The suffocation of men who have descended into sewers or gas-wells is a fact of abundant record. Numerous instances have occurred in this country, some within my own personal knowledge, of men engaged in gas-works, descending into what is called the gas-well to look after the attachments leading to the main distribution, having been suffocated and lost their lives, not in consequence of any specific poisonous property that attaches to the illuminating gas as such, but that they were drowned in the irrespirable gases. They are irrespirable in the sense that they are insufficient of themselves, or even in the presence of atmospheric air, to sustain life, acting by exclusion of the atmospheric oxygen, and this is wholly irrespective of the question as to whether there may or may not be in the carburetted hydrogen gases portions of other substances, which are specifically poisonous in the sense that term is used by toxicologists.

Q. In the same sense, are not the gases evolved from spent lime when exposed to the air irrespirable? A. They are clearly.

Q. In your opinion, is sulphuretted hydrogen decomposed in the air? A. Yes, sir; decomposed or recombined. I would say, it may be decomposed or recombined with other substances in the air. Sulphuretted hydrogen, or compounds of that gas with ammonia, are always present in in the atmosphere of cities. A fact familiar to every housekeeper is that silver is speedily blackened by exposure to the atmosphere of our houses in towns, which is attributable to the presence of sulphur compounds in the atmosphere.

Q. Do you regard Berzelius as a standard authority on the subject of gases? A. I do.

Q. In the fifth edition of his work, vol. i., page 849, Berzelius says that sulphuretted

hydrogen is not decomposed by dry oxygen? A. I did not say it was; I did not make any any such assertion as that. You asked me if sulphuretted hydrogen might not be decomposed in the air. I said yes; but the atmosphere is not dry oxygen.

Q. How do you suppose sulphuretted hydrogen to decompose in the air? A. There are various transformations of sulphuretted hydrogen in the air; it may be combined directly with ammonia or the carbonate of ammonia, both of which are liable to be present in the atmosphere from natural causes, in which case it would exist as sulphide of ammonium. In the presence of watery vapor it may be transformed by oxidation. I wish to add to that another point, which is a fact familiar to every chemist, that the solution of sulphuretted hydrogen in water cannot be kept for any length of time, because of the transformation or decomposition of that compound, accompanied by the precipitation of free sulphur, due to the combination of the hydrogen of the sulphur compound with the free oxygen dissolved in the water. The same transformation of sulphohydric acid occurs in the atmosphere, and from the same cause, viz., the oxidation of its hydrogen in moist air.

Q. Is there much watery vapor in the atmosphere during the cold season? A. The atmosphere is never without watery vapor.

Q. Is there as much? A. There is less during the dry, cold weather than during moist, warm weather, of course.

Q. Berzelius states, in the same volume, same page, that a single cubic inch of sulphuretted hydrogen is sufficient to make its presence apparent in all parts of a room by its disagreeable odor. Do you doubt this? A. Is the size of the room mentioned?

Q. In the case of a large room? A. Terms are comparative. If by a large room he means a room of this size, I say yes; but, if he means the Academy of Music, I say no.

Q. This sulphuretted hydrogen withstands decomposition for a certain length of time in the air? A. Yes, sir; it is wafted upon the winds a certain distance from sulphur springs, but not to a very great distance. I spoke of those springs near Rome, and in the neighborhood of Avon and Sharon.

Q. Same vol., page 852, Berzelius says: "Thenard, referring to the poisonous character of sulphuretted hydrogen, remarks that a bird died in air containing 1-1500th part of its volume of sulphuretted hydrogen, and a dog in air containing 1-800th part." Do you agree with the statement? A. Yes, sir; I do not admit the presence of free sulphuretted hydrogen in atmosphere containing ammonia. That is a point of difference between my friend Dr. Chandler and myself.

Q. Your statement as to the offensiveness of effete lime exposed to the air would apply to the process as conducted by the Metropolitan Gas-Works, would it not? A. It would.

Q. Are you aware of any special precautions being employed at those works, to prevent the spent lime from becoming a nuisance or offensive? A. Beyond the exercise of a reasonable vigilance and cleanliness about their purifying-house—in this respect I find the works in commendable order—I found no special precautions.

Q. There are none of the special precautions to which you refer? A. No, sir; there are not.

Q. Could not the Metropolitan Gas Company, with very little trouble or expense, abate, or effectually prevent this nuisance in the way described by you, or by some other method? A. The offence complained of in the case of the Metropolitan Company may certainly be abated at no very large expenditure of time or money; it will take some time, and take some money, and without new causes of offence, or new causes of unhealthiness. Certainly I should like to add to that answer, that, in my judgment, they are entitled to a reasonable consideration in the time requisite for the effecting of such changes; they, of course, involve new constructions, and some expense.

Q. Is from the 15th of July last, to the present time, a reasonable time to make the changes? A. If the changes in question had been contemplated in July, they certainly could have been effected by this time; my familiarity with the case, however, dates from the 5th of February, I think. If they had entered upon such a process of reconstruction in July, they should have had it in efficient action long ere this; I cannot say, however, of my own knowledge, that, in the interim, they have not taken some precautions—that is more than I know.

Q. As an expert, you would recommend improvement in the ventilating process now employed there—would you not? A. They have none.

Q. Would you recommend the introduction of the ventilating process? A. I should recommend the introduction of a well-considered plan of ventilation, as the only efficient and sufficient cure for the evils complained of.

Q. You have recently visited the works? A. I have.

Q. Have you seen there any preparations for the introduction of such an improvement? A. Not to my knowledge; my attention was not called to any such; the remark was made that they were about moving certain masses of coal and buildings, with a view to new constructions.

Q. For what object? A. I did not inquire; it appears that the company have four extra purifiers—had at the commencement of this year.

Q. Could they not adopt the iron process in a much less period of time than that required for the ventilating improvement you mention? A. They have two sets of four boxes each at the present time, two of the older and two of the newer form of construction. There is not room in their existing houses for the iron process. There is not sufficient space, as I conceive, for the display of the mass of effete iron for reoxidation. It requires a very considerably enlarged area over the ordinary lime process to spread out the mass of spent iron, and revivify it. And that space does not exist in the present buildings. I should think the time consumed in suitable preparations for the iron process would not vary much from that which would be required for ventilation. I said I thought three months ought to do it.

Q. Could they not introduce the oxide of iron there, as it should be used to purify the gas. Could they not in a very short time? A. As I understand your question, it would contemplate the use of successive doses of iron material, as they now use successive doses of lime material.

Q. Could they not arrange to do that in a very short space of time? A. I think that that of course would be met with almost unsurmountable difficulties, for this reason, that the iron process does not work so well in the first action as in the second, third, and fourth. It improves to a certain point in quality, and, therefore, you would always be at the worst point if you were always to renew it.

Q. Suppose they had proper facilities for revivification, would there be any difficulty in introducing the iron process at once? A. None occur to me.

Q. What is the difficulty of using the space which they now occupy for their refuse lime for the purpose of revivification of their iron? A. I am not sufficiently familiar with the economy of the works exactly to say what the proper answer to that inquiry is.

Q. Is any peculiar machinery or buildings, or any thing of that kind, needed for revivification? A. Nothing but a shelter.

Q. A shed? A. Yes, sir; you want a somewhat steady temperature. That is, you would not wish it exposed to the outer air.

Q. I believe nothing has been said of the kind of lime used by yourself. A. In America we always use oyster-shell lime.

Q. What is the advantage of oyster-shell lime? A. It is an exceedingly fine form of lime. Its subdivisions or laminations render it peculiarly favorable.

Q. Is there any necessity of that shell-lime being fresh? A. It must not have been carbonated; it must be fresh hydrate of lime. Practically it is used as fast as it is burned.

Q. Is not the oyster-shell lime used because it is cheaper? A. I don't think that is a primary consideration. No, it is not cheaper. For instance, in Portland it is not cheaper than stone-lime.

Q. Is it used in Portland? A. I can't say it is; but I say in a lime country you can get stone-lime cheaper.

Q. Where you can get stone-lime, do they use stone-lime or shell-lime? A. I think that question would be decided by the relative economy.

Q. Are there not a great many portions of the world where they cannot get shell-lime? A. In England they use stone-lime almost exclusively.

Q. In what period of time will one hundred feet of gas, in its consumption, pass through an ordinary burner? A. It depends upon the size of the burner.

Q. Fix the size of the burner and fix the time. A. In a burner using five cubic feet, of course it would be twenty hours.

Q. I want to know what is the ordinary burner used in the house, how much? A. Their name is legion, if you mean the volume of gas they consume.

Q. Yes, sir. A. The volume of gas consumed would average from four to five feet.

Q. Therefore, it would take twenty hours on an average to burn one hundred cubic feet of gas? A. Yes, sir.

Q. With fifty grains of sulphur in that one hundred cubic feet of gas, is it your opinion that there is any injury to health from that amount of sulphur, in that amount of gas consumed? A. I never said there was any injury to health. It is a nuisance. The combustion, in the house, of gas containing sulphur occasions irritation to the eyes.

Q. Is gas purified by dry lime ever free from naphthaline? A. I think that is dependent on the temperature at which gas is made, and the variety of the coal from which it is made. Gas that is made from poor coals is never free from naphthaline. As you approach the limits of the law in England, in the matter of elimination, you increase the risk of precipitating the naphthaline which is held in solution in ordinary gas in virtue of the presence of the richer illuminating hydrocarbons; hence, gas which is made from poor coal is always more likely to let fall its naphthaline, and to occasion trouble to the gas engineer and to consumers, from the obstruction of the pipes by this crystalline compound, especially in cold weather, than gas which is made from rich coals.

Q. As the business of manufacturing gas in this city is conducted, is not naphthaline present? A. I conceive that naphthaline is almost uniformly present in coal-gas, and that it is a very important constituent of coal-gas. It being a powerful illuminator, the objection to it being, as I stated, that, when from false views of economy, or other reasons, poor coal is employed, the naphthaline, which ought to be sustained in the gas in the permanent form, is precipitated, and the loss of the naphthaline is a loss to the consumer.

Q. Is there any sanitary objection to its presence? A. I don't think there is. It is rather an agreeable thing to me to smell naphthaline as a perfume.

Q. Is there probably more than a trace of phenol in gas as it reaches the purifier? A. I have never examined that question personally.

Q. What is your opinion? A. I certainly should not expect the presence of any large quantity of phenol in the gas, though there is reason to believe it may be there in a sensible quantity.

Q. What becomes of the greater part of the phenol produced by the decomposition of coal? A. It is found in the coal-tar, and associated also with the tarry portion of the lime, or other agents of purification, in the purifying-boxes. I brought to this room last week, but I am not certain that it was exhibited, a bottle containing lime richly charged with tar from one of the purifying-boxes from the Manhattan Company, in proof that the tar is condensed in the purifiers, and Dr. Bowditch says you can always obtain from the best purified gas in London a portion of tar by methods which he gives, and I add that, with the tar, there is a legitimate portion of phenol. Phenol is the creosote of coal-tar.

Q. What will become of the minute trace of phenol remaining in the gas after purification, after the gas is burned? A. I suppose it must be exhaled among the effete products of combustion. I suppose it goes to watery vapor.

Q. Is it not quite probable that it will be burned with the gas? A. It is certainly possible.

Q. Is it not a good illuminating agent? A. It is.

Q. Is it probable that any possible nuisance could result from its presence in ordinary practice? A. No.

Q. Have you any reason for believing the oxide of iron is less efficacious in removing the phenol than the dry lime? A. I have no experimental reason.

Q. Have you any other? A. I have an impression that the phenol would be more apt to rest with the lime than with the iron. Still, that is an impression not founded upon the result of any experiments, and I do not attach any value to it.

Q. Is there any chemical reason supporting such an impression? A. It is rather hard to

analyze one's convictions on any thing of that sort. An impression rests in my mind upon the general knowledge of the subject. There is a compound of phenol with lime. I don't know that there is any with iron. There is just where the point of departure on the impression arises. Chemistry is an experimental science preëminently, and experiment does not always substantiate the theoretical exceptions of chemists; sometimes it does more.

Q. Is not this substance considered the best antiseptic found in gas manufactories? A. I so stated in my direct examination, and gave examples.

Q. And is it used in such practice? A. Yes, sir, in the practice of antiseptics, and in the preservation of meats, and so on.

Q. Is it not probable that the carcasses you mentioned in your direct testimony, as not likely to undergo decay in the purifying-houses, would be preserved by phenol, and not by sulphuretted hydrogen and not by sulphide of ammonium? A. I intended in that testimony to convey the distinct impression that it was the phenol that would act as the antiseptic generally, and never the sulphuretted hydrogen.

Q. Is there any thing in phenol or its properties which renders the question, whether more or less of it would pass by the lime or iron process, of any importance to this investigation? A. No, I think not.

Q. Then the introduction of the question of phenol you would leave out entirely? A. I think it is a very interesting question, but I don't think the public health is prejudiced in the least by it.

Q. Is the phenol given out to the atmosphere from the effete lime in any way so as to have a practicable or perceptible effect upon the atmosphere? A. The proper answer to that question would involve experimental data, of which I am not possessed.

Q You have no knowledge that it is given out? A. No personal knowledge.

Q. Have you any theoretical knowledge? A. I think that in the decomposition of the lime it would be given out.

Q. So as to have any practicable or perceptible effect on the atmosphere? A. I revert to my testimony in regard to the effect upon carcasses.

Adjourned to Thursday, the 18th instant, at one o'clock.

THURSDAY, *February* 18, 1869.

Prof. Benjamin Silliman, recalled. Cross-examination resumed.

Q. Is not acetylene burned or destroyed in the combustion of the gas? A. Not always; on the contrary, acetylene is produced in the combustion of gas, if that combustion is in any considerable degree impaired. For example, in the ordinary wire-gauze gas-stoves, which are so frequently used in warming small apartments and in cooking, acetylene is produced in very notable quantities, as has been proved long since by Berthelot; and there is reason to believe that acetylene is also produced under other conditions than those of the wire-gauze gas-stove; when the supply of oxygen is imperfect, or from any reason, as from the presence of carbonic acid; perhaps it may be from an insufficient supply of oxygen gas. This fact has been very lately brought to our notice afresh by a recent Memoir of Berthelot, which is published in the proceedings of the "Paris Chemical Society." The title is now changed to the "*Bulletin de la Société Chimique.*"

Q. As gas is ordinarily consumed, is acetylene produced in any considerable quantity? A. The question is answered in a reply to your previous question. Berthelot, in the last memoir above referred to, affirms that, in the ordinary bat's-wing burner as ordinarily used, acetylene may be detected. I have not verified this statement myself, but Berthelot is such an excellent authority that I would not question his accuracy.

Q. In Dingler, vol. clxv., p. 149, Berthelot states that gas contains but a few ten-thousandths of acetylene. Do you agree with that statement? A. How recent a number of Dingler is that?

Q. 1862. This is a copy of Berthelot's original article. A. I accept whatever statement Berthelot makes, as an authority.

Q. Do you regard its removal from gas a matter of any importance in the quantity in which it generally exists? A. I regard its presence in gas as very undesirable, and that

whatever tends to its production should be carefully avoided, for I believe it is fully in proof that the presence of small quantities of acetylene in the atmosphere where gas is burned, and resulting either from the distribution or combustion of gas, is proved to be particularly prejudicial to health and comfort, and that it induces headache and sickness, and *malaise*, which is complained of by those who inhabit rooms which are warmed by unventilated gas-stoves. It is one efficient cause of *malaise*.

Q. Do you regard it as any more injurious than the smell which arises from the burning of kerosene? A. I am not aware that the smell which arises from the burning of kerosene is injurious. It is disagreeable and offensive. I never experienced any ill effect from these odors. Nobody of choice disseminates ill odors of any kind in apartments.

Q. Have you any good reason for supposing acetylene to be any more injurious than the odor just spoken of? A. Yes, sir. I think that is clearly in proof that it is not merely an ill odor, but a poison acting on the nervous system. I do not know that any one asserts that the odor from burning petroleum is a poison.

Q. Your objection applies more particularly to cases where gas is applied to stoves? A. The production of acetylene under those circumstances is far more notable—more abundant.

Q. Does it not appear in gas purified by lime as well as by iron? A. I dare say it does; I have detected it in gas purified by lime.

Q. Have you not detected it in gas purified by iron? A. I never have. I have never had the opportunity; I have never seen that process in operation, except at the New York Gas-Works, and under circumstances not favorable to experiments. I simply consider it the duty of gas companies to render gas as free as possible from every source of objection that can properly be raised against it as an article of consumption in houses. It is unquestionable that in the United States we consume gas in our domestic life far more commonly than is done in England. It is still a comparatively rare circumstance in England that gas is used in houses, and the prejudice against it in London when I was there, which was several years ago, was very strong, and chiefly, as I believe, because they had been so ill-treated by the metropolitan companies.

Q. Do you mean to state that the dry-lime process is the only one which removes carbonic acid from the gas? A. No; the wet-lime process removes carbonic acid very perfectly, and the Laming process may remove carbonic acid also, perfectly, if it is properly conducted; but I conceive that no iron process which is entirely without the presence of lime will purify gas completely of carbonic acid.

Q. Would not Laming's iron process as applied in London effectually remove the carbonic acid? A. I judge from my readings only, for I have never had an opportunity of observing it personally, that Laming's process is capable, when properly conducted, of depriving the gas of its carbonic acid, but that, in fact, as ordinarily conducted, it does not.

Q. I limited it to the London application. A. I speak of it exclusively as applied in London. My inference is founded upon my readings of the discussions of that subject in the English journals. I know that the complaint is general, in London, of the low quality of the gas as respects illuminating power, and that the statement is constantly reiterated that the gas does contain a notable portion of carbonic acid. It is true that the Metropolis Gas Act requires only 14-candle power, which we should consider very low.

Q. You stated that the oxide of iron of the New York works evolved ammonia; where did it get this? A. I do not recollect what I stated in my direct testimony; of course the ammonia must come from the gas.

Q. The oxide of iron does, then, absorb the ammonia from the gas? A. It does.

Q. Is there any affinity between lime and ammonia? A. There is; there is a double compound of lime and ammonia—the carbonate of lime and ammonia, a salt distinctly recognized. At the same time, every chemist understands perfectly that the action of quick-lime is to decompose ammoniacal salts and set ammonia at liberty, and it is for that express purpose that quick-lime and sal-ammoniac are employed for the evolution of ammonia. In the ordinary dry-lime purification, the ammonia is of course in the largest measure removed by the water of the hydraulic main and the water of the scrubbers, and but a small portion of the whole product finds its way into the purifying-boxes, and that chiefly as a sulphide of

ammonium. I believe I have already explained that method of decomposition sufficiently—the ammonia and the effete lime.

Q. Has not iron a positive and well-recognized affinity for ammonia? A. It has—the hydrous sesquioxide of iron, which is a common iron-ore, is well known to absorb and retain it with obstinacy, and this property it possesses in common with ordinary clay, and it is to this joint effect that Liebig and other agricultural writers attribute the peculiar value and efficiency of clay in soils for the retention of ammoniacal salts.

Q. Has not iron a stronger affinity for ammonia than lime? A. Certainly.

Q. In your direct examination, in stating the advantages of the lime process over the iron process, you gave as a reason that the lime more effectually removed the sulphur, carbonic acid, and ammonia; what reason had you for embracing ammonia? A. The ammonia is not removed in the lime process as ammonia. It is not in that form that it occurs in the lime purifying-boxes. It exists there solely as sulphuret of ammonium or ammonic sulphide, and it is from the decomposition of this salt, under the conditions which I have already described, that the powerful ammoniacal odor arises which is exhaled when the atmosphere commences its action upon the effete lime. I think I remarked in the same connection, as as far as I can now recall my testimony, that I did not regard the presence of a small proportion—say not exceeding four or five grains of that substance in one hundred cubic feet of gas—as in any degree prejudicial to the consumer; but, on the contrary, that I thought its presence to a moderate extent—not exceeding that amount—desirable, and that it was even desirable that there should be so much present that it would react upon turmeric paper, for the important reason that the presence of ammonia under these conditions secures the sulphur in a harmless form, since in the combustion of the sulphur the whole of that product appears as sulphurous acid. If ammonia is also present at the same instant, the two substances unite in the form of sulphite of ammonia, a salt which is white and harmless, and may be often seen condensed upon the under side of the metallic belts that are hung above the chimney of an argand burner. The coating which lines the chimney, when it is moist and freshly made, and which may be seen afterward, when dry, as a frosty-looking deposit, is the salt of ammonia produced in the manner which I have indicated; and hence I regard the presence of the small trace of ammonia which is usually found in gas as rather beneficial than otherwise. The allegation, that it produces nitric acid or nitrous acid in its combustion, appears to me to be of doubtful application; at all events, I have never seen the evidence of the presence of nitric acid under these circumstances.

Q. Then you do not regard its presence in gas as an objection to the iron process? A. Not at all—no, not to the extent specified. It is, of course, quite possible for the gas manufacturer to send his gas to the consumer so imperfectly purified of ammonia that its presence shall become a nuisance. It is then altogether probable that nitric acid vapors will be produced in a noticeable quantity, and a peculiar greenish, non-luminous character given to the color of the flame. This may be recognized by the eye. I have often observed it, as every other careful observer must have done, in noticing gas in the act of combustion.

Q. That impurity would be more likely to exist in gas purified by lime than that purified by iron, would it not? A. I do not know that it would.

Q. Is it not true that the London gas purified by iron is claimed to be remarkably free from ammonia? A. The parliamentary act—the gas act—allows the presence of five grains of ammonia; and I observed in a recent discussion on that subject, which took place within the present month in London, that a distinguished gas engineer, Mr. Hawksley, speaks of the presence of ammonia as being easily recognized, by turmeric paper, in the London gas. I do not remember of what particular company he spoke. I have quoted Mr. Hawksley as the authority. It occurs to me since doing so that it might possibly have been one of the other gentlemen who were involved in that discussion, which took place on the occasion of Dr. Odling's lecture before the Board of Health. In the *Journal of Gas-Lighting*, published at London, July 7, 1868, page 524, Dr. Odling says: "The next constituent of coal-gas to which I shall call your attention is ammonia. The proportion of ammonia in London gas is very small. We find that one grain of ammonia in one hundred cubic feet of gas is sufficient to affect turmeric paper, upon which ordinary London gas is used, without, or almost without,

action." Q. Would you regard Dr. Odling an authority upon that question? A. I have quoted him as such. I was going to quote him against himself. I have his lecture of the 2d of February, 1869, here.

Q. The gas referred to by him is purified by iron. Is it not the ordinary London gas he speaks of? A. He does not say so, but I presume such is the fact. With your permission I will read what Dr. Odling says in his lecture before the Metropolitan Association of Medical Officers of Health, published in the *London Journal of Gas-Lighting* for the 2d of February, 1869.

Q. What does it refer to? A. This question of ammonia.

Q. The presence of ammonia in gas? A. Yes, sir. It is in support of what he says before: "I suppose I must say that all coal-gas contains some ammonia—that is to say, it contains some, chemically speaking, so that, if it were required to recognize it, ammonia might be detected in any coal-gas whatsoever. The greater part of the coal-gas supplied in London, however, contains but a very small portion of ammonia. The act of Parliament requires that coal-gas shall be so free from ammonia as not to affect turmeric paper, and ordinarily the gas in London either does not or only just does affect turmeric paper. When we bear in mind the extreme delicacy of this test—I think that it has been calculated that one grain of ammonia in one hundred cubic feet of gas will affect the test-paper decidedly—you may infer that the ammonia in ordinary gas, where it does not or does only just affect the test-paper, is so small as to allow of its being disregarded. At the same time, where the ammonia does exist in any quantity, it is certainly objectionable. There is no doubt that by its combustion it produces a certain amount of nitric acid, which is prejudicial in many ways, and that the ammonia itself is prejudicial to the brass taps and fittings."

I believe that is the latest testimony we have on that subject. I would remark in that same connection, that I have lately determined the quantity of ammonia in gas, which I have been making, under a series of experiments, in connection with Prof. Wurtz, in New Haven, with the hydrocarbon process, and I have found that it amounts to but little more than half of one grain in one hundred cubic feet of gas, but that the gas which is furnished to the city of New Haven, being made by a different process, is considerably richer in ammonia, although still within the parliamentary restriction.

Q. How much richer? A. I cannot give you the figures until I calculate them: I have them in my pocket. I have not calculated the result.

Q. Does it color turmeric paper very distinctly? A. Very decidedly—very distinctly. The other does not; it does not affect the turmeric paper at all. It falls within the observation of Dr. Odling, that one grain of ammonia in one hundred cubic feet of gas will affect turmeric paper.

Q. Then it must contain more ammonia than the London gas? A. I think it probably does, but I am not prepared to say that as of authority, for I have not the exact figures.

Q. I believe you have already stated that the New Haven gas is purified by the dry-lime process? A. Always.

Q. In the fifth edition of Clegg's "Treatise on Coal Gas," published in New York in 1868, page 196, he states: "By none of the processes of purification we have described is bisulphide of carbon effectually removed; nor has any process yet been discovered by which gas can be purified on a large scale from this compound of sulphur. The Metropolitan Gas Companies have consequently been unable to comply with the conditions required by the Metropolis Gas Act of 1860, that the gas shall not contain more than twenty grains of sulphur in every one hundred cubic feet. The gas companies who supply the city of London applied to Mr. Barlow, in 1864, to ascertain whether it was practicable by any known process to abstract the sulphur compounds so as to attain the required standard of purity. Mr. Ellisen, the chemist of the experimental works of the Paris Gas Company, instituted numerous experiments with that object, but the conclusions they arrived at were not encouraging." Would you agree with Clegg in that statement? A. Not entirely, for reasons that I would state. My own experiments upon the presence of bisulphide of carbon or carbonic disulphide in coal-gas have not been such as to leave upon my mind the impression that this form of sulphur is of so frequent occurrence as is stated in nearly all literature on gas chemistry.

I have diligently sought for that product by the best accredited methods, in the case of the company of which I am the chemist, in New Haven, and in gas which I had especially made by experimental processes, from various sources, for myself, and I have not detected it. I do not mean to be understood to say that it does not occur, or occur frequently, in London gas; chemical testimony about that point is explicit; but I do mean to be understood as saying, that I do not regard it as by any means so frequent or of so universal occurrence as is stated. I believe at our last interview (as well as I recollect my testimony) that I made the statement which I now repeat, that there was, in my judgment, good reason to believe that the form in which sulphur more frequently exists than in any other in coal-gas, was that of sulphocyanide of ammonium—the combustion of course resulting in the production of sulphurous acid. I also stated, as I believe, in my direct testimony, that it was the current opinion of the best gas engineers who have written upon this subject, as far as I know, that the lime process is more effectual in removing the sulphur than the iron process; and the evidence, as produced in the discussion before the British Association of Gas Manufacturers, which was quoted on a former occasion, was adduced in support of that opinion; and that opinion I now reiterate, that it is not possible for the iron process so closely to remove the sulphur, as it is ordinarily conducted, I mean, as in the dry-lime process. If the dry-lime or other lime process is added as a supplement to or a portion of the iron process, then the sulphur will be as effectually removed in the one case as in the other.

Q. Dr. Letheby, in his quarterly report on the supply of gas in the city of London, given in the *London Journal of Gas-Lighting*, July 21, 1868, page 562, states that the average quantity of sulphur has not been excessive, though in 46 out of 160 cases the quantity of this impurity exceeded 20 grains per 100 cubic feet. The Great Central Company's gas averaged 14.54 grains, the Chartered Company's gas averaged 18.86, and the City Company's gas averaged 18.97 grains. Do you regard that statement as authoritative? A. Of course—it is official.

Q. Do you regard the proportion given in that statement as excessive. A. It falls as an average within the parliamentary act. In that sense it certainly is not excessive.

Q. The companies referred to in this statement do not use the dry-lime process, do they? A. I presume not. It is a point granted, that in London they use the iron process exclusively.

Q. Do you consider Prof. William Odling, Professor of Practical Chemistry at Guy's Hospital, and Secretary of the London Chemical Society, an authority upon practical chemistry? A. I have already had the pleasure of answering that question more than once, and I shall be happy to reiterate, as often as you repeat it.

Q. Have you read the following statement by that gentleman, on page 562 of the journal last cited, July 21, 1868? A. I presume I have. I read the article at the time of its appearance—the same being in his lecture to the British Association of Gas Managers:

"So far, then, I am a little at issue with gas managers in being disposed to admit, that ordinary coal-gas contains a geater amount of sulphur in some form or other than they are willing to allow, and than the letter, though not the spirit of the act of Parliament, permits; for the act was framed upon the results furnished by an incomplete combustion of the gas, and condensation of the products. But, on the other hand, I am altogether at issue with the public when they maintain that the sulphur of gas produces, by its combustion, oil of vitriol, or that the amount of sulphur ordinarily contained in gas is of any consequence whatever; and a little consideration will, I think, satisfy you of the soundness of this position. We will assume that coal-gas contains, not 20 but 40 grains of sulphur in 100 feet—a quantity at any rate greatly exceeding the reality. Now, making the extravagant assumption, that the whole of these 40 grains of sulphur would be completely burned—and in reality they would be burned very incompletely—they would furnish by this combustion 80 grains of sulphurous-acid gas. This quantity of the produced sulphurous acid would occupy, at ordinary temperature, about one-fifteenth part of a cubic foot, and since 100 cubic feet of our coal-gas gives one-fifteenth of a cubic foot of sulphurous acid, 1,500 cubic feet of our coal-gas would be required to furnish one cubic foot of the acid, even upon the extravagant assumption we have purposely made. But the combustion of 1,500 cubic feet of coal-gas

would produce something besides sulphurous acid. It would produce, at least, 1,000 cubic feet of carbonic acid, and, in addition to its dilution by other gases and vapors, we should have our sulphurous acid diluted by 1,000 times its volume of carbonic acid. Now, if we can get at the proportion of carbonic acid in the atmosphere of a room highly illuminated with gas, and take the 1,000th part of that proportion, we shall be able to form some notion of the amount of sulphurous acid present. You will remember that the amount of carbonic acid furnished by the breath of one individual is equal to that furnished by two three-feet gas-burners, and that the maximum amount of carbonic acid found in the atmosphere of a crowded theatre was .32 per cent. Now, if, in addition to our previous unreasonable supposition, we further suppose that an atmosphere contains .2 per cent of carbonic acid furnished by gas combustion, you will see that the whole matter becomes a *reductio ad absurdum*—that we might actually have one half-millionth part of sulphurous acid present in the air of a gas-lighted room.

"But this sulphurous acid is not sulphuric acid, and can only be converted into sulphuric acid with very much pains and difficulty, as all who have tried the experiment of converting the sulphur of coal-gas into sulphuric acid are painfully aware. When gas is burned in special apparatus, indeed, its constituent sulphur can be converted into sulphuric acid; but it is very difficult to do this. The probability is, that of the sulphurous acid produced, in ordinary combustion, scarcely a particle gets converted into sulphuric acid—certainly not more than the ammonia ordinarily existing in the atmosphere can neutralize, so as to form sulphate of ammonia instead of sulphuric acid." A. Yes, sir; I am familiar with the statements alluded to.

Q. Is not sulphurous acid an excellent disinfectant? A. No. I do not know that I should rank sulphurous acid as a disinfectant. I recognize it as an excellent antiseptic. There may be some confusion of terms in this regard. I regard chlorine as an excellent disinfectant, but I do not propose to fumigate my parlor with it.

Q. In the pamphlet on the application of disinfectants on arresting the spread of the cattle plague, by William Crookes, F. R. S., at page 20, is the following statement, entitled "Sulphur Fumigation:"

"Of all disinfecting processes this is perhaps the oldest. Its action was well known in the days of Homer, for we read that Ulysses employed it to remove the smell of dead bodies. It is recorded by Ovid, that the shepherds of Italy yearly purified their flocks and herds with burning sulphur, and passages in other writers show that they averted diseases from them by this means."

Would you agree with that statement? A. I believe that sulphurous acid is a very powerful agent in destroying the germs and spores from which contagious and other diseases are propagated, and have so stated in my testimony already given.

Q. Is not an agent that removes infection, as you state, a disinfectant? A. I suppose it would ordinarily be so classed, still the terms are used with a good deal of vagueness. Sulphurous acid is a well-known specific agent for the cure of cutaneous diseases, a property which it enjoys in common with sulphur, from which it is produced, and for fumigation in hospitals, for which purpose it is of long standing and with satisfactory results.

Q. Are you confident that the smell you perceived near the ceiling in the room where gas was burning, as described in your direct examination, was sulphur? A. I did not say it was sulphur; I said it was the smell of sulphurous acid and sulphite of ammonia, producing the well-known choking effect which makes the stifling atmosphere observed in an ill-ventilated room in which numerous gas-lights are burning. I did not say it was sulphur—it is a very different thing.

Q. You stated that when the oxide of iron is ventilated in the purifiers it becomes heated and sets fire to the screens—is any difficulty of this kind experienced in the New York works? A. In the New York works the iron is not ventilated in that manner. It is ventilated upon the floor. They do not ventilate their iron in boxes—the case is entirely distinct.

Q. Then there is no necessity of ventilating the iron in the purifiers? A. Not unless you wish to prevent a stink.

Q. What stink did you refer to in your answer? A. That which is described as so noisome by some English authorities as exhaled from the effete iron.

Q. You never noticed that. A. I referred specially for authority to the description of the Rev. Dr. Bowditch.

Q. You did not notice that offensive smell in your visit to the New York Gas-Works? A. No. My recollections in regard to the visit in question are a little indistinct, as I have stated in my direct testimony. I remarked on that occasion, that I visited the works for the purpose of examining into the economic character of the process, rather than its sanitary character, and paid but little attention to the stench.

Q. You are not aware that the oxide of iron used in the gas-works at Copenhagen is daily ventilated in these boxes? A. I know nothing about the Copenhagen works.

Q. You stated that you visited the New York works last summer, among other things to ascertain the economic value of their process—what experiment did you then and there make? A. I made no experiments other than the ocular observation of the character of the gas which I noticed in the photometer room, or dark room, in which I found it burning.

Q. How did you know then that the gas produced at these works was not as pure as when purified by lime? A. I only inferred, from the investigation of the gas, that it was a gas of low quality, and that as such it undoubtedly contained a portion of carbonic acid to which its low illuminating power was attributed. It is well known that the presence of even a moderate quantity of carbonic acid very greatly depresses the illuminating power of gas.

Q. Could you detect the difference of one or two candles in the illuminating power of gas, without the aid of the photometer? A. Two candles very readily, unless the gas was of very high or low illuminating power; anywhere between the range of twelve and sixteen or twelve and eighteen candles, I could detect with my eye the difference of two-candle power readily. That is a matter of habit which grows upon one from constant use of the photometer, and daily personal observations with which I am familiar.

Q. In the German edition of Muspratt, vol. iii., at page 1522, is the following statement which I will ask Prof. Chandler to translate.

(Professor Chandler translated as follows:)

In speaking of the material used in purifying gas, Muspratt states that—

"Of all these materials, Laming's mixture and the iron-ore have obtained the most general or prominent introduction. Laming's mixture has, above all others, particularly lime, essential advantages. After being once used, it can be regenerated and used again. According to Unruh's experiment in Magdeburg, the purification from sulphuretted hydrogen takes place so completely that one cannot detect the smallest trace by the most delicate reagents, and the quantity of carbonic acid in the gas is extremely small—the illuminating power not less than when lime is employed; and the smell of the foul mass trifling."

Do you regard that as good authority? A. I do not know the author of the article in question—whether it is attributed to Dr. Muspratt or to the German editor, Kerl. I can only say that it is a difference of opinion between many authorities, and that this statement is at variance with the current literature of English gas engineers.

Q. From the same author and volume, page 1523, is the statement that Prof. Chandler will read, entitled "Purification with iron ore:"

"This ore is often cheaper or more easily obtained than Laming's mixture, and is regenerated at first slower and afterward more rapidly. At the new city gas-works in Berlin, the ore obtained in Upper Silesia is employed. In the gas-works at Hanover the fine pulverized ore of Lunenberg mixed with spent tan and refuse dye-wood is employed."

Do you regard that statement as authoritative? A. I regard it in the same light as the other statement by the same author. It is an illustration of the difference of opinion that competent authorities entertain with regard to the same method.

Q. Do you recognize "Wagner's Chemical Technology" as good authority? A. I do.

Q. At page 699 of that work it is stated that, "much more important than all the previous methods of purification and really establishing an era, is the process of R. Laming in 1847."

Q. Do you regard Bloxam as good authority? A. He is a good chemist.

Q. In his Chemistry, at page 450, referring to Laming's process, he says: "A great many other methods have been devised for the purification of gas from sulphuretted hydrogen, but none appear to be so efficacious and economical as that which consists in passing the gas over a mixture of sulphate of iron (green vitriol or copperas), slacked lime, and sawdust, which latter is employed to prevent the other materials from caking together. The lime decomposes the sulphate of iron, forming sulphate of lime and hydrated oxide of iron." Would you agree with that statement? A. So far as I know, the statement is correct. I mean, of course, in that answer that it is a correct statement of Laming's process, so far as I understand it. I do not necessarily give in my adhesion to the inference which he draws from it.

Q. In Wagner's "Year Book of Chemical Technology," vol. ix., page 713, it is stated in regard to the cheapness of the lime process. He simply states that the expense of purification is reduced to nothing by virtue of the value of the sulphur which is extracted from the foul oxide. Have you any reason to doubt that statement? A. I have no reason to doubt the statement, though I have never seen that statement confirmed elsewhere. It has often been mentioned, as an advantage of the iron process, that the sulphur could be extracted from it.

Q. In Bowditch's work on the use of coal-gas, London edition, 1867, at pages 19, 20, and 21, are the following statements:

"About this date the use of gas was increasing very rapidly" (that was in 1844, the date referred to), "the gas companies in London, and in some of the large towns, were sadly encumbered with and troubled about the lime-refuse which arose from purifying their gas. Purified, the gas must be. Sanitary regulations most properly prevent the running of blue Billy —wet-lime refuse—into streams and rivers, and in some cases prohibited the carting away, from gas-works, of dry-lime refuse during the daytime. Matters seemed to be approaching a crisis, when, in 1849, Mr. Hills came to the rescue and introduced hydrous sesquioxide of iron as a purifying agent instead of lime. * * *

"When a certain quantity of sulphur has been set free in a mass of oxide of iron it becomes useless—not because its chemical affinity for sulphuretted hydrogen is destroyed or even lessened, or because the ore has lost the power to restore it when it is foul, but because it is clogged with inert sulphur. Mr. Hills further showed that when thus useless as a purifying agent the oxide yet had a value, for the accumulated sulphur could be converted into sulphuric acid, and for this purpose the oxide was worth what it cost at first, and in some cases I believe even more. This was an enormous boon to urban gas companies. It delivered them from a great difficulty in reference to the foul lime, and taught them how to free their gas from sulphuretted hydrogen, without any cost for material to do so. * * *

"The use of lime after the oxide would remove the carbonic acid from gas, and need not produce any nuisance or involve more than a nominal cost, as the lime might be fit for use for the removal of carbonic acid over and over again. The evolution of the sickening vapors emitted by foul oxide need not be a serious annoyance, as the oxide can be revivified in the purifiers themselves, or in a building whence all effluvia can be carried through fires into the atmosphere, so as to be harmless." Do you agree with the statement read? A. I accept Mr. Bowditch's statement of the iron process as an exhibit of its claims, but I observe that he recognizes the noisome exhalations which the iron gives forth, and suggests a method for their removal which is essentially the same thing which has been recommended already for removing the similar nuisance from lime—a method of ventilation which was tried here in the Manhattan Company, and blew up the chimney which they built for the purpose, and destroyed considerable property.

Q. In the "Manual of Elementary Chemistry," by George Fownes, late Professor of Practical Chemistry in University College, London—the London edition of 1868, edited by H. Bence Jones, and Henry Watts—at page 180, he says: "The use of lime, however, has been almost superseded by that of a mixture of sawdust and iron oxide." Do you agree with that statement? A. I do. That is an historical statement of the condition of the art in Great Britain and Europe.

Q. Do you recognize Professor E. D. Mapother, M. D., as a good authority upon sanitary science? A. Yes.

Q. In his lecture upon public health, Dublin edition of 1867, at pages 53, 54, and 55, are the following statements: "In both the gas-works the mode of purification had been by the wet-lime process, and the resulting refuse was conveyed into open tanks for the purpose of allowing the undissolved lime to settle from it. This lime was afterward used as luting for the retorts, and the water is pumped under the furnaces, where it is consumed. At the open part of the sewers in Benson Street, which has been recently covered in, about thirty yards from where the boy was suffocated in July, 1864, this refuse-water might have been often seen. I believed that sulphuretted hydrogen escaped from the tanks while the refuse was exposed to the air, from the luting of the retorts, and from the water while being dried upon the furnace-pans, and I am convinced that such escape was most injurious to the health of the workmen and surrounding population. My opinion was painfully verified by the suffocation of three men by sulphuretted hydrogen, in a pit dug on the premises of the Alliance works, in September, 1865. The lime-refuse must have percolated from the tanks into the surrounding earth. Unwilling that so great, and in the beginning so expensive, a change should be urged upon the companies, without my opinion being supported by London and other authorities, I wrote to the Medical Officers of Health of nine English districts. All condemned the lime process, and approved of the iron process, except one eminent chemist, who stated that with proper precaution the wet-lime process need not be a nuisance, injurious to health. I also consulted several eminent gas engineers, and quoted authorities such as 'Muspratt's Chemistry,' 'Barlow's Chemistry of Gas-Lighting,' 'Hughes's Treatise on Gas-works,' and thus produced much evidence upon the noxious character of the wet-lime process in a populous town. In order to determine the matter by personal inquiry, the corporation commissioned me to examine the works in London and other English towns, during October, 1860, and I accordingly visited the London, City of London, Phœnix, Equitable Chartered, Imperial, York, and Scarboro works, and ascertained that in all the lime process had been found to produce nuisance, and that, therefore, the oxide-of-iron process had been substituted. * * * The only company which we now have has entered into a contract for the erection of purifying chambers by the iron process, during summer, when alone extensive changes can be made in gas-works, and they will be in action immediately."

Q. Do you accept these statements as authoritative? A. I understand these statements as applicable in the instances cited about the wet-lime process. I do not understand that the wet-lime process is on trial here. Nobody proposed to introduce that. It is not used in more than two or three companies in the United States, as I have before stated; and it is, where the blue Billy cannot be disposed of at once into the ocean, an unquestionable nuisance.

Q. Would not the fact, that the authorities spoken of by this author introduced the iron process in preference to the dry-lime process, go to show that they did not deem the dry-lime process as furnishing the remedies? A. They have been compelled by the municipal regulations to introduce the iron process into most of the towns of England. It is not from choice, but from necessity, as I understand, that this change has been effected in the majority of the cases.

Q. What authority have you for stating that the Metropolitan Company use Boghead coal in the manufacture of their gas? A. I saw the coal there, and obtained a portion of the coal there for my own use.

Q. Was not that temporarily used? A. I only mentioned Boghead as one of the enriching coals that they used.

Q. The inference might have been that they were in the habit of using "Boghead." A. They used, I said, either "Boghead," or "Wigan," or "Lesmahago," or some other well-accredited cannel-coal. All those I saw there and could speak of from my own knowledge. That is my authority—my own personal observation.

Q. Is your opinion, that the gases evolved from refuse lime employed in the purification of gas are harmless, based upon actual knowledge of the effect of these gases upon the blood? A. It is based upon an actual knowledge of the effect of these gases upon living men—human

beings—in the vicinity of the gas-works, and through a long course of observation. I have never made any experiments as to the effect of the introduction of this gas into the arterial or venous system of man. I believe my opinion of that subject was fully expressed on the occasion of our last interview in answer to a question which the learned counsel addressed to me, in respect to Dr. Ure's testimony in regard to parties being suffocated in a pit.

Q. You spoke of them as being drowned in the gases? A. Yes, sir.

Q. How far from the gas may sulphide of ammonium be floated before it becomes so transformed as not to be perceptible to smell? A. No very considerable distance.

Q. It would vary, I suppose, with the varying conditions of the atmosphere? A. Compared with the distance to which the heavy and persistent odors of the hydrocarbons are floated, to which just objection is made on the score of offence.

Redirect examination by Judge Van Vorst:

Q. I would like to ask you whether the process called the Laming process is in use in the United States? A. Not to my knowledge. The only gas-works that to my knowledge certainly is employing an iron process is that one which has been so often mentioned in the city of New York, and they do not employ Laming's process, but a modification of the English or European iron process, in which, as already explained, a variety of bog-ore or sesquioxide of iron is mingled with a certain proportion of iron turnings, the whole mass drenched with ammonia-water, and mingled with charcoal and exposed to the atmosphere after oxidation, for the purpose of revivification.

Q. You know nothing about Laming's process except as you have read of it in gas literature? A. I have never had the opportunity to study Laming's process, and know it only by reading.

Q. Do you know by reading whether it is adopted in Europe to any extent? A. I believe it to be adopted to a considerable extent in some parts of Europe.

Q. In some parts of Europe, Professor Silliman, do you know any thing of what the advantages or disadvantages of it are, as compared with the dry-lime process. A. I believe I have already pretty fully stated my opinion upon that subject in the direct testimony, and also in the cross-examination.

Q. Now, with regard to the wet-lime process of which you have spoken—that you say is in use in Boston? A. In Boston, and in use in Providence.

Q. Do you know whether it is in use in any other part of the country? A. I do not know it to be in use elsewhere than in those two places.

Q. In your opinion the fouled lime, unless it may be removed by being cast into the ocean at once, is a decided nuisance? A. It is a very decided cause of offence.

Q. How would it compare with the dry lime in that respect? A. In that regard, it is more offensive than dry lime. It does not present the same opportunity for removal. This fouled lime must be removed in close vessels of some kind, or, if suffered to remain in sewers, or in streams, it would become a very just cause of offence.

Q. You stated that the ventilation of the oxide of iron in the boxes destroyed the boxes? A. That is a statement which has been very frequently quoted in my direct testimony.

Q. If it could be ventilated in the boxes, the noisome odors of which you have spoken might be avoided? A. Undoubtedly, if a system of ventilation could be adopted, which would prevent the too high temperature, I see no objections.

Q. You say there had been an experiment, as you understood—something toward ventilating it in the boxes—tried by the Manhattan Company with regard to the lime? A. Yes, in the case of lime.

Q. Did they not attempt to ventilate the lime there in the boxes? A. The case to which I alluded is this: They attempted to adopt substantially what is known as the Palmer process of ventilation, which consisted in expelling the air which had been drawn through from the boxes, carrying with it the offensive odors into the bottom of the stack or chimney provided for that purpose, with the expectation of burning it in that stack; but the result was an explosion, resulting from the mingling of the gas and the atmospheric air, which destroyed the stack, and blew the engineer out of the window and damaged property to a considerable extent.

Q. And, subsequently to that, they have made additional improvements? A. They have adopted an entirely different method of ventilation, which has already been explained in the previous testimony.

Q. Now, do you know whether that method of ventilation of the fouled lime adopted by the Manhattan Company, of which you have spoken in terms of commendation, prevails anywhere else in the United States or in Europe? A. I am not aware that has been adopted anywhere else in the mode it has been adopted there.

Q. Do you regard that, then, on the part of the Manhattan Company as an experiment? A. I regarded it as a successful experiment.

Q. But as an experiment nevertheless? A. It is an experiment of their own introduction. I do not regard it as an experiment, if that implies a doubt of its success.

Q. Would you regard that as an improvement? A. Yes, sir.

Q. Do you know whether it is or is not the subject of a patent? A. I do not know any thing about it.

Q. How late is it that that method of ventilation of the fouled lime in the Manhattan Company has been communicated to the public, to your knowledge? A. It has been well understood among gas engineers and persons interested in gas purification for more than a year that the Manhattan Company had achieved a success in that direction.

Q. But the details of it were not known? A. I think not. So far as I know about this, there has been no detailed description of the method or its operation, as of authority.

Q. It has not made its way into the literature of the art, as far as you know? It has not entered into the gas literature of the day? A. It is not to be found, as far as I know, in any of the gas literature of the day; I think the description, which we have given in this discussion here, was the first which came before the public in a formal manner.

Q. When did you see it first yourself? A. I first saw it some time during last summer, perhaps it might have been in June.

Q. Then you first visited the works—first became acquainted with the fact that they had this method? A. I have been in the habit of visiting the Manhattan Works for a great many years, but I visited them for a knowledge of the new system of ventilation last summer; and more recently I have visited them again.

Q. At that time it was regarded by them as a success? A. Yes, sir. The engineer spoke of it to me as being an experiment at the time.

Q. But subsequent experience has proved it to be measurably successful? A. Yes, sir. They are so well satisfied with it, that one of the officers told me last week, they contemplate the coming season to erect new sheds to cover the necessary revivifying boxes.

Q. They produce much more gas in the Manhattan Company than they do in the Metropolitan Company? A. I think four or five times as much.

Q. And use four or five times as much lime for purification? A. Yes, sir.

Q. Whatever there is offensive about the manufacture of gas—if there is any thing offensive about effete lime—it would be magnified at the Manhattan Works? A. Yes, sir. My recollection is that they consume one bushel of lime to every 3,600 or 3,700 cubic feet of gas, and that the daily make of gas is 5,000,000 cubic feet.

Q. The oxide of iron at the New York Works was, you say, on the floor. A. Yes.

Q. It was not ventilated in the boxes? A. No, sir.

Q. And whatever was objectionable in regard to its emanations and exhalations went into the atmosphere? A. Of course.

Q. Of whatever character? A. Yes, sir.

Q. As you went there for the purpose of regarding the process in its economical bearing, you were not sufficiently informed as to that? A. No, sir.

Q. You have been inquired of by Colonel Hastings, as to the article of William Odling, Professor of Chemistry at Guy's Hospital, and the article has been put into your hands for examination. Now, sir, will you please to state in what regard, if any, you differ from Prof. Odling in regard to that method? A. Dr. Odling has rehearsed with great detail the whole matter of the chemistry connected with the combustion of gas in houses, on the occasion of the recent meeting of the Metropolitan Association of Medical Officers of Health.

Q. How recent, professor? A. At a meeting of the Board of Health held in Fleet Street, London, in January of this year, as I understand.

Q. Subsequent to the article (to which your attention has been called) of his, July, 1868? A. That article was the substance of an address which he gave before the British Association of Gas Engineers. This is substantially the same as the former lecture, but is somewhat more in detail, as it is in print, particularly the consideration of questions connected with the consumption of gas in houses relative to domestic use. With his customary clearness and exactness of statement, Dr. Odling, in this very interesting communication, which extends over five columns of the *Gas-Light Journal*, goes minutely into the consideration of all the important questions raised by the subject of discussion, and, among others, he rehearses what has been before quoted with respect to the amount of sulphur which is contained in gas; and, following this communication is a discussion of the points of the lecture, in which Dr. Letheby, Mr. Hawksley, Mr. Findlay, and others, took part. Dr. Letheby, whose name is even more intimately associated with the subject of gas chemistry than is that of Dr. Odling, and who is the gentleman to whom we are indebted for some of our most important methods of analysis in gas chemistry, takes exception to the remarks of Dr. Odling, in respect to the importance of the sulphur product resulting from the combustion of gas, meaning thereby, of course, the products of sulphurous and sulphuric acids, which are evolved in its combustion. With your permission, I will submit a few of Dr. Letheby's remarks in detail. In the *Journal of Gas-Lighting*, London, February 2, 1869, page 83, he says: "And now, I am desirous of making a few remarks on the effects of sulphur in coal-gas. Dr. Odling has directed your attention to this matter from a statistical point of view, and has shown you how, by a mathematical process, the amount of sulphur-acids in the products of burning gas may be reduced to a vanishing point, and that, therefore, they must be insignificant and wholly harmless; but I will ask you to look at the subject from another point of view, and to examine it in the light of facts as well as of figures. About fifteen or twenty years ago, when I began to inquire into this matter, I was struck with a circumstance which is now, as it was then, very remarkable—namely, that, wherever gas is burned continuously, and in large quantity, it causes a rapid destruction of textile fabrics, with a very acid condition of them. This is notably so in our public libraries, and in ware houses and shops. I obtained so many striking proofs of this, especially from the libraries of the Athenæum Club-house, the London Institution, the College of Surgeons, and elsewhere, that I made them the subject of a special report to the city authorities in 1854, and here you will see the specimens of covers of books which were furnished to me at that time. If you apply a piece of the leather to your tongue, you will taste its acidity, and if it be treated with water or spirit of wine, and tested with a solution of baryta, it will be found that the acid is sulphuric acid. These effects were observed many years ago, in the library of the Athenæum Club-house, and they were growing to be so serious that the managers requested a commission of chemists, including Dr. Prout, Mr. Aiken, and others, to inquire into it, and I have before me a copy of their report on the subject. It is to the effect that the mischief is clearly due to the presence of sulphuric acid, which had come from the burning gas; and they state that the mischief will continue as long as gas is used in the library without proper ventilation. Mr. Faraday thereupon designed the system of ventilation, which is still used in the library. As to the effects of the products of burning gas on shop-goods, they are notorious, for such goods are regularly disposed of as damaged or gassy things. It has been remarked, too, that plants are quickly killed by the products of burning gas, for they are peculiarly susceptible of injury from the presence of sulphurous acid in the air; according to Drs. Christison and Farmer, as little as one part in 10,000 of air will kill plants in less than twenty-four hours. And you cannot use gas in a conservatory, either for heating or for illuminating purposes, unless the products of combustion are entirely removed. Dr. Christison has written to me very strongly on this subject; and he attributed the absence of flowers and plants from the rooms of Edinburgh to the circumstance that gas is universally used in them. Advancing a step further in my inquiries, I ascertained lhat the water produced by burning gas, collect it how you will, is always acid, and will rot teather, paper, cotton, and linen. Here are specimens of such tissues, which have been

dipped in the condensed liquid products of gas combustion, and you will observe that they are as rotten as tinder. Lastly, I contrived a plan whereby the amount of sulphur in coal-gas could be estimated. I had thought that the instrument was sufficiently well known, and the *rationale* of its action thoroughly understood; but the instrument, which Dr. Odling has placed upon the table, and has described to you as my ingenious contrivance, is so different in all its essential particulars from my own instrument, that I disown it, and call it an ingenious perversion of the apparatus which bears my name. I know from experience that such an instrument will not discover half the sulphur that is really present in coal-gas; and I have no doubt that the discrepancies, which have lately been referred to by writers on this subject, have been occasioned by the use of such an instrument as is now upon the table. The particulars of my instrument, the measurements of the several parts of it, and the mode of using it, are fully described in Mr. Sugg's book on gas manipulation, and, if it be used in a proper manner, it will discover all the sulphur of the gas; and thus it will be found that the amount of sulphur may reach to from thirty to forty grains per one hundred cubic feet of gas. If the presence of sulphur in such quantity in coal-gas was an unavoidable necessity, and could not be reduced by any reasonable process of manufacture or purification, it would be folly to complain of it, other than to show the necessity for good ventilation where gas is burned; but this is not the case, for there are processes of purification which will easily diminish the amount of sulphur to less than half the usual quantity. Mr. Hawksley, whose presence this evening will, I hope, be useful to us, by his giving us the result of his large experience in this matter, has shown that, by copiously washing raw gas with ammoniacal liquor, it is possible to remove a large proportion of the sulphur compounds of gas without injuring in the slightest degree its illuminating power. After this treatment the gas should be deprived of its sulphuretted hydrogen by means of hydrated oxide of iron, and then, while a little ammonia is still remaining in it, it should be further purified by passing it through dry lime, which is the slightly moistened hydrate of lime. In this way the ammoniacal liquor is strengthened to a high degree—it being rarely less than of 10 oz. strength—by the absorption of ammonia compounds, and by the removal of sulphur in other forms than that of sulphuretted hydrogen. The hydrated oxide of iron is also less foul than it usually is, and is capable of revivification, without annoyance; while the hydrate of lime is actually inoffensive, for it contains nothing but carbonic acid, sulphocyanogen, and sulphur, produced by the reaction of ammonia on bisulphide of carbon in the presence of caustic lime. Mr. Hawksley will tell you, what I also know from experience, that by these means the amount of sulphur in coal-gas is easily and certainly reduced to about 10 or 12 grains per 100 cubic feet of gas. It is easy, as I have said, to meet this question by a numerical argument, and to show by a mathematical process of reasoning that the amount of sulphur in gas may be made to vanish almost entirely; but I would rather examine the practical or experimental facts, and endeavor to remedy what is among practical men an acknowledged evil, by applying those remedies which are clearly within our reach."

In that connection I desire to present to your notice a quantity of sulphur by actual weight, such as the English law allows, viz., 20 grains of sulphur to each 100 cubic feet of gas.

[A weighed portion of 20 grains of sulphur was here offered in evidence, and package marked "Exhibit B."]

You will observe that it is by no means an insignificant quantity regarded as a material substance. I may say that, if that quantity of sulphur were suddenly burned in an atmosphere no larger than that in an ordinary sitting-room, the air of the room would be insupportable. But it is worthy to be remembered that that quantity of sulphur is actually set at liberty in the form of sulphurous acid in about five hours' time in an evening, in a room which is lit by four ordinary gas-burners of the capacity of five feet each, and that it is in evidence from Dr. Letheby and others, that the gas may even contain 30 or 40 grains in every 100 cubic feet. It is always to be remembered that the largest product in bulk, which is given off in the burning of gas, is water, in the form of watery vapor; and that this watery vapor takes up and absolutely retains sulphurous acid, and rests upon the windows, upon the paint, and upon the hangings, if there are any; and upon the books and bindings that are in

the room, and that in the upper portions of the room it is especially noticeable, owing to the temperature, resulting from the combustion and the warmth of the room, that these products are most abundant.

In this connection Mr. Hawksley remarked, in the discussion before alluded to, that—

"He was enabled to state that, by the use of ammoniacal liquors for the purpose of washing the gas, and by the use of lime in the process of purification, the sulphur could be reduced, without any sensible depreciation in illuminating power, to as little as ten grains in one hundred feet, that was to say to as little as one half the quantity which was allowed by the act of Parliament. Now, it might be said that this was not worthy the attention of professional men in that room. It was said, and said with some truth, that the gas companies had been driven away from the use of a very valuable agent by persons who complained that the use of lime in the purification of gas was a nuisance. They had consequently been driven to employ the oxide of iron, which was a very imperfect agent for the removal of some of the compounds; and the general result was that, in order to free our streets from the occasional smell of foul lime, we put sulphur into our dwelling-houses. He did not think it was any improvement in a social sense at all, and it was always desirable to ascertain whether, in effecting changes which might be proposed, and which might appear to be beneficial, we were not producing injurious effects in another direction. However, such had been the results. He did not think, with regard to the question of the presence of ammonia, that any notice whatever, in the present state of the manufacture of gas, need be taken of that agent. The quantity was so small, even in the gas which was the worst purified, in the sense of the removal of ammonia, that he did not believe any effect at all—any appreciable effect—detrimental or otherwise, would arise, and he would say this with regard to the alleged effect of gas upon books and furniture, and other articles of that sort, that, although he believed there had been a considerable effect produced when gas was very much more purified than it was at the present day, yet he believed there were now other causes operating to produce the effect, which were at least as great as gas, if not greater. The quantity of coal consumed in London gave off more than 6,000 tons of sulphur into the atmosphere every year, and so large a quantity as that must in itself produce a very sensible effect; in point of fact, we know it. But, besides that, we must not forget the influence of temperature. With a large quantity of gas burned in a room, near the ceiling, unless special means of ventilation were adopted, the temperature would be very high indeed—so high that it would be impossible to exist in it for many minutes, perhaps not for one. Well, now, that had a very serious effect upon books and furniture, and he attributed very much of the rottenness of books—always greater on the higher shelves than on the lower—to that cause. He believed gas had been very largely discredited in consequence of other influences, which did not proceed from the combustion of gas itself." * * * *

"Mr. Findlay said he had been connected with two of the largest gas companies in London for sixteen or seventeen years, and he quite agreed with the remarks of Mr. Hawksley about the use of lime. It was a question whether they ought not to go back to the old practice. It was well known that there was no better process of purification than by means of wet lime, or dry lime; it must always be a nuisance to a certain extent."

By *Mr. Van Vorst:*

I don't know whether it was taken down or not, but I understood you to say in your cross-examination, that gas in London was not consumed in the dwelling-houses to any thing like the extent that it is consumed in the dwelling-houses in this country. A. That was the case when I was familiar with London; and it is not to this day, as I am assured, esteemed fashionable to hold a ball, or reception, or entertainment, in the evening with gas The houses are lit then with wax-candles, and there is still a prejudice in London, to a great extent, against the use of gas in houses, to a much greater extent than is known in this country.

Q. Is there any thing more you wish to say? A. I think the subject has received sufficient ventilation without trespassing on the time of the honorable referee any further.

By *Mr. Hastings:*

Q. Is not the quantity of sulphur left in the gas after purification very largely caused by

the kind of coal employed in the manufacture of the gas? A. Not necessarily. The amount of sulphur compounds produced is directly as the amount of sulphur in the coal but the amount of sulphur left in the gas depends largely on the method of purification If the gas is improperly purified, of course the amount of sulphur it contains will be greatly increased. The difficulties and the cost of purification, and the time which is consumed in the act of purification, are all greatly increased by employing a coal which, in the technical language of the coal-house, is dirty. Dirty gas is likely to be the consequence. There are many coals which, but for the large amount of sulphur they contain, would be very desirable indeed as gas-coals, but they are inadmissible, from the reason referred to. This remark is true of most Nova Scotia coals, some of which will yield as high as four and a half cubic feet of gas of excellent illuminating power, but, by reason of the large amount of sulphur which the coal contains, it is found not economical or profitable to employ it. I beg leave in this connection, as you have brought the subject up, to call your attention to an important paragraph in Clegg, which Dr. Chandler will at once remember. On page 197, he states in a single instance that "one of the anomalous results obtained in the experiment"—alluding to experiment made by Mr. Palmer and Mr. Ellison, which you have already quoted—"that the quantity of sulphur present in the coal does not bear any proportion to the sulphur compounds in the gas produced from it."

Q. Other things being equal, would not a coal, containing twenty per cent. of sulphur, yield a gas containing more sulphur products than that produced from a coal containing only ten per cent.? A. I conceive that the answer to that inquiry is properly conveyed in my former answer. The quantity of sulphur products would of course be in proportion to the amount of sulphur contained in the coal, but that which would remain in the gas would not be necessarily greater. In this paragraph which I have just quoted is a single sentence perfectly in point: "Thus it appears that the gas obtained from the Denain coal, from the neighborhood of Valenciennes, which contains 31.10 pounds of sulphur in one ton, gave a maximum of 7.48 grains of sulphur per 100 cubic feet, while the gas from Stavely coal, containing 26 pounds of sulphur in one ton, yielded 22 grains of sulphur to 100 cubic feet of gas." It appears, therefore, in answer to your question, that there is no direct ratio between the amount of sulphur contained in the coal and that which will be found in the gas—that the coal which contains a less proportion of sulphur as an original constituent, than another coal, may yield a gas which contains less sulphur by constitution than the gas produced from another coal containing a larger amount of sulphur.

Adjourned to Saturday, February 20th, at one o'clock.

TESTIMONY OF PROF. HENRY WURTZ.

SATURDAY, *February* 20, 1869.

Prof. Henry Wurtz, called and sworn on behalf of the Metropolitan Gas-Light Company; examined by Judge Van Vorst:

Q. Where is your residence? A. My residence is in New Jersey; my business in New York City.

Q. What is your vocation and profession? A. I claim to be a chemist; call myself a scientific and practical chemical expert.

Q. How long have you studied the subject of chemistry? A. About twenty years, sir, more or less.

Q. With what institutions have you been connected in the practice of your profession as a chemist? A. I was at one time in Yale College, as assistant to Prof. Silliman, in what was called the Scientific School at that time, at Yale College; I was Professor of Chemistry in the National Medical College at Washington; Professor of Chemistry in the college at Kingston, Canada; Chemical Examiner in the United States Patent Office, where the subject of gas came before me practically.

Q. Have you given particular attention to the subject of the manufacture of coal-gas? A. I have, sir.

Q. Have you studied the subject of its purification? A. I have, sir.

Q. Have you observed the subject of purification practically? A. Within th e las

year I have spent a considerable amount of time on various occasions in examining processes of purification on the ground, if that is to be understood as studying it practically.

Q. Are you familiar with the lime process of purification—dry lime. A. I am, sir.

Q. And with the method of purification by the oxide of iron? A. Yes, sir, so far as a gas chemist can become familiar with it in this country, I presume: the only place that I am aware of where it is used being the works of the New York Gas-Light Company in this city, which I visited on two occasions when they were using the process, and had permission to examine into the minutiæ of its workings.

Q. The dry-lime process of purification is that which is in use in the United States, is it not, sir? A. So far as I am aware, with the exception of two or three gas-works, in which the wet-lime process is used.

Q. One is in Boston, is it not? A. One is at Boston, and one, I think, at Providence; but the last account I received from the Providence Works they were proposing to substitute the dry lime.

Q. When was that? A. Quite recently—within a fortnight—I heard the fact; I have no special knowledge, however, in the matter.

Q. I would like to ask you what are the results of your observations of the lime and iron processes for the purification of gas; you may speak of it in a scientific point of view and also in a sanitary point of view. A. With regard to the scientific points involved, sir, I would remark that I believe the ground has been so thoroughly gone over by Prof. Silliman, that I should have little to add, and the more especially so as a great portion of the same ground has already been gone over by me in print, and, therefore, I would propose to present a copy of a report made by me to the Manhattan Gas-Light Company during the last summer, made in manuscript, and which they printed about the first of December, or the latter part of November last, and of which I have some printed copies here.

Q. Will you produce a printed copy of that? A. I have several here.

(Prof. Wurtz produced a printed copy of the report, which was offered in evidence.)

Q. In that report do you discuss the claims of the two systems of purification—the lime and the oxide of iron? A. I do, sir; I would remark, with regard to this report, that in this report there is brought forward some account, intelligible at least to gas chemists, of the new process which has been spoken of here previously by experts.

Q. At this hearing? A. Which has been spoken of previously by other experts, not at this hearing, but a previous hearing—the process of the Manhattan Gas-Light Company—there is, however, no specification given of this process, as I understand the meaning of the term specification, in a technical and practical sense; in fact, such specification was purposely omitted by me. I did not feel authorized or called upon to present such a specification.

Q. Specification of what? A. This method of purification; such a specification as would render it possible for a gas engineer to put it into practice.

Q. Do you mean of the Manhattan Company's process—of ventilating the effete lime? A. Yes, sir; the question may be of the ventilation of effete lime; nevertheless, the principle of the process could be understood by gas chemists, and I should mention that this pamphlet has quite recently—within six weeks—been republished, or copied by the London *Journal of Gas-Lighting*, and has, consequently, actually become a part of the current literature of gas.

Q. When was this report of yours published? A. So far as my memory serves, it must have been about the 20th of November, 1868, that it was printed; it was circulated though, I believe, only in a private way.

Q. Have you any reason to alter your opinion now, as expressed in this report made by you? A. The only essential addition that I would suggest is to add to the substances which are extracted largely by hydrate of lime from the gas, the constituent called naphthaline, which is not extracted to so large an extent by oxide of iron. Allow me to read one of the paragraphs from this pamphlet.

Q Which page is that? A. On page nine; I present, in the form of some conclusions, in one paragraph, this one: "It thus appears that of those constituents of crude coal-gas, which may be viewed as contaminations, and whose separation is desirable, there are no

less than four of the most objectionable, which, while distinctly under the control of the lime process, cannot be shown to be separable by any recognized or reliable chemical or other agency residing in oxide of iron; these four are carbonic acid, ammonia, bisulphide of carbon, and phenol;" and to these I would now venture to add naphthaline.

Q. These four contaminations, then, you say, are distinctly under the control of the lime process, and are eliminated by it; is that so? A. The results of the examination appear to show that. I would also add: I find in my notes that I mention the nitrogenous and sulphuretted odorous matters of the gas which are complained of.

Q. What do you say about those? A. I have no reason to suppose that the oxide of iron retains these in any form, although they are largely retained by hydrate of lime.

Q. Well, then, I suppose you mean the oxide of iron is a very imperfect purifier; a low purifier with regard to the carbonic acid, ammonia, bisulphide of carbon—phenol, and naphthaline, you would add? A. Naphthaline, and at least a portion of these specially odorous compounds which form the subject of complaint by the public.

Q. You adopt the pamphlet now, then, as a part of your testimony in this case, and offer it as such? A. Substantially.

Q. Have you said all that you designed to say about it, in a scientific point of view, or is there any thing further to be added in that respect? If not, then you may proceed to state the result of your observations from the sanitary point of view? A. I would add the following remark: In the present condition of the subject, a fundamental consideration for the gas chemist is, that before any final decision as to the adoption of a method in a large gas-works, on the smooth workings of which so much depends, a precise chemical solution should be arrived at of all the questions and problems involved. This would take time. Realizing this, I have recommended it to the gas companies, and especially to the Manhattan Gas-Light Company; and I might add that the chemist of the Board of Health, Prof. Chandler, was invited to join in this investigation. This investigation has not yet, however, made much progress. Other matters have intervened.

Q. What is the state of that investigation now? A. I regard all these proceedings *here* as a portion of that investigaton; and an essential portion, an important portion, a valuable portion, and a fortunate portion of that very investigation.

Q. What results will proceed from it, in your judgment? A. The ultimate results, I doubt not, if it is carried on in a right spirit, and with diligence, will be the removal—the entire suppression of all the unpleasant consequences resulting usually from the impurities in the purification of the gas, and the improvement of the quality of the gas at the same time.

Q. Will you speak of the result of your observations of the lime and iron processes for the purification of gas from a sanitary point of view? What are the advantages or objections to each process? A. First, I would prefer to make one or two general remarks: It is understood by myself, and, I believe, by the public generally, that formal and deliberate accusations have been brought against the Metropolitan Gas-Light Company, to the effect that they have been guilty of negligence affecting the health and the life of portions, at least, of the community. I regard these accusations as pure fantasy, while, at the same time, I would not deny the existence of a bad odor by any means. That would be absurd—quite as absurd in the opposite direction; neither would I deny the necessity of exercising all due diligence and exhausting science in preventing the escape of this bad odor—a subject which is occupying the attention, I may say, of gas chemists all the world over at the present time, but which is by no means satisfactorily solved, unless we may regard the process so very recently developed by the Manhattan Gas-Light Company as a solution. I may say that I individually do regard that as a solution, and so stated in the pamphlet referred to; and the other gentleman brought forward as an expert concurs, it would appear from his testimony, fully with me in this. I would add, that I have never met with any evidence pointing toward the truth of this accusation of any deleterious or detrimental action upon health, or any injury to health, or danger to health, arising from the emanations from gas lime under ordinary circumstances. I have remarked that I consider this a fortunate investigation. I consider it fortunate to the Metropolitan Gas-Light Company, because it gives them an op-

portunity to purge themselves from these accusations of having injured the public health and endangered life. These accusations, if true, would really amount to accusations of a criminal negligence. I might add, that the experts who have testified in the case have already been attacked, by implication, in the newspapers, for aiding the Metropolitan Gas-Light Company, and that is one reason why I make these deliberate remarks. Now, with regard to the sanitary bearings, I will take the several substances in order: First, carbonic acid. The view has been presented in the course of this investigation, that a small proportion of carbonic acid in the gas is of no importance in a sanitary point of view. I would say, in my opinion, as an expert, this remains to be proved, and that the probability is that any thing which impairs the rapid and complete combustion of the gas in a confined room is extremely likely to be injurious to the health of the occupants of the room. To ammonia the same remark applies as to this; but, at the same time, I do not regard it as of any very great importance. Prof. Silliman has already suggested an important beneficial action which ammonia exerts, when left in the gas, in neutralizing to a certain extent the products of the combustion of sulphur, which always remains in the gas in a greater or less quantity—of sulphide of ammonium. This is the most important constituent which we have to deal with, doubtless, in a sanitary point of view. Both the lime and the iron processes, doubtless, extract these completely from the gas when properly applied. The very fact that the oxide-of-iron process extracts it at all is a sufficient answer in the mind of chemists to the allegation that has been made that there is free sulphuretted hydrogen in the gas. It is difficult to understand how oxide of iron could absorb sulphuretted hydrogen—free sulphuretted hydrogen from the gas, except in the presence of an excess of ammonia, and then it becomes not free sulphuretted hydrogen, but sulphide of ammonium. The consideration of the sulphide of ammonium, then, is narrowed down to its effects in the material used for purification, and its after-effects upon the atmosphere. In the case of oxide-of-iron purification, the effete iron, when taken out of the purifier, is believed to contain a large quantity of sulphide of iron, It may contain some ammonia. As Prof. Silliman has already stated, it is well known that hydrated oxide of iron does absorb ammonia to a certain extent, though not by virtue of any definite chemical affinity that has ever been pointed out. As I understand it, just as clay, dust, or any finely-divided material, as, however, all the sulphide of ammonium is converted by the oxide of iron into sulphide of iron and free ammonia, and chemists would expect that some of the ammonia set free would travel on from the iron purifiers with the gas. I am not aware, however, that the chemical points involved in these considerations have been worked out satisfactorily. I am drawing inferences from theoretical considerations in a great measure. When the effete oxide of iron is exposed to the air, then we have a mass of sulphide of iron, which immediately attracts oxygen from the air, producing heat and burning. There is a danger here, which seems inherent in the process; that the heat may become so high as to set fire to the mass of sulphur, and sulphurous acid would be produced by the combustion of the sulphur. This danger probably increases in proportion as the mass has been revivified and reëmployed. It is alluded to in some of the works upon the subject, as a difficulty now undergoing investigation, and being probably gradually mastered. I have here a work, recently published by Zerah Colburn, on the gas-works of London, in which he states, on page 50: "Sulphuret of iron precipitates its sulphur on exposure to the air, and again combines with oxygen, occasionally with such energy as to take fire." On page 55: "The precipitation of sulphur and the resumption of oxygen are occasionally so rapid, especially when the material has been used a few times, that it smothers and actually enters upon active inflammation." In the latter case the sulphur vapor is almost overpowering. On page 57: "At the Commercial Works, however, Mr. Jones has his apparatus in readiness, and may have already commenced, indeed, to revivify Hill's oxide in his purifiers." The date of this is 1868.

Q. The author, then, is speaking of the method of purification by oxide of iron, is he not in this instance? A. Yes, sir, in London. This is a practical work very recently published, and the impression gathered by a gas chemist is, that the subject of the revivification of oxide of iron is not yet reduced to such a certainty as to avoid with certainty this difficulty of catching fire of the great quantities of free sulphur which are thrown out of these purifiers

and the consequent diffusion of great quantities of sulphurous acid throughout the neighborhood of the gas-works. In the case of the lime purifier the sulphide of ammonium is largely absorbed as such, and appears to form a compound with lime, or with sulphide of calcium, as yet not investigated or understood by chemists. On exposure to the air this material undergoes oxidation also, the main substance given off being free ammonia, which carries with it, however, some sulphide of ammonium. I have heard no evidence yet brought forward, and I have met with no evidence in all my readings, of any deleterious effects from sulphide of ammonium. I have here a sample of sulphide of ammonium. Any gentleman can test the effect of it upon his nose and lungs by actual experiment. Here is a very concentrated solution of sulphide of ammonium, containing, as it almost always does, when it has been standing some time, free sulphur in solution, indicated by the yellow color, and some free ammonia. I am enabled also to present a solution containing sulphurous acid, upon which some remarks have been made here, and upon which I have some further remarks to make, as an exhibit to be tested by gentlemen who are now familiar with it. The effect upon the nose and eyes is very distinct, though the odor is not very strong, and the effect upon the throat is very marked in producing a choking sensation, and, if persisted in for a few inhalations, very violent fits of coughing are produced. This gas is simply the same as is given off by a brimstone match, familiarly known as fumes of burning sulphur—brimstone fumes—and the suffocating quality of [illegible] every one is familiar with. I shall have more to say about it subsequently.

The next substance which I wish to speak of is phenol. I am not aware that phenol is absorbed by oxide of iron. I am not aware either that its presence in the gas is detrimental either to the illuminating power, or in a sanitary point of view, but it is well known to be absorbed with some considerable power by lime, having an affinity for lime by virtue of its analogy to alcohol, and forming a weak compound, somewhat similar to what are known as alcoholites. When the effete lime is exposed to the air the phenol is doubtless given out again, sooner or later, from the absorption of the carbonic acid by the lime, to the displacement of the phenol. I should consider it preferable that it should be given out in this way, rather than to be distributed with the gas to the consumers, as its odor is disagreeable to most persons, and extremely persistent, and has the nature of adhering to substances for a long time, as every one who has ever had the toothache knows familiarly, who has used it for curing toothache; it is generally called creosote, although it is not creosote but it is sold for creosote, and used for the same purposes, and is similar to it. Gas containing phenol, when leaking, as gas is very likely to do, or let out into the atmosphere, would doubtless have a tendency to leave a more persistent odor than well-purified gas. Phenol is accompanied by other substances, one of which is known by the name cresol, which has a somewhat different odor, but at the same time very persistent.

The next substance I wish to speak of is naphthaline. Naphthaline appears to be absorbed largely both by the oxide of iron and by the lime. There is always danger of too much of it being absorbed by the gas. Its illuminating power being very high, one of the evils of over purification is the abstraction of too much naphthaline from the gas, and the impoverishment of it. At the same time it is dangerous to leave very much naphthaline in the gas, particularly when the gas is not of a very high illuminating power. Poor gas containing much naphthaline frequently would deposit naphthaline in the main, and endanger the supply to the community by choking the mains; hence, I should prefer a process which would abstract from a very rich gas enough naphthaline to prevent this danger, and not abstract enough to impoverish the gas. Gas engineers have generally found the lime process to answer these requests. When a poor gas is in question, experience has shown that naphthaline has a tendency to deposit in any case.

The next substance is bisulphide of carbon. There is much difference of opinion as yet among gas chemists about the relations of this substance to gas, which I attribute to the overlooking of many of the results of the earlier investigators of the substance. I have gone back to those older writings—those of Berzelius and Zeise on this subject. Not to go into the chemistry of the subject in detail, I will merely say that we have here evidence sufficient to justify us in believing that hydrate of lime extracts all the bisulphide of carbon from gas.

Q. How is iron, the oxide of iron, acted on? A. There is no evidence of any action upon bisulphide of carbon by this.

Q. No affinity between the oxide of iron and the bisulphide of carbon? A. Not that I am aware of. Bisulphide of carbon is an especially dangerous and injurious substance in gas, as it is not detectable by any simple means—as lead-paper for instance. Second, it is inodorous. When pure, almost inodorous. In the atmosphere it decomposes and develops an insupportable odor, the cause of which is not well understood, probably owing to the development of hydrogen compounds: as I may say Prof. Silliman has recently pointed out in an item published in the *American Gas-Light Journal.* Bisulphide of carbon, when burning, is converted into sulphurous acid; the sulphur in it is converted into sulphurous acid. There is no reason to believe that it does not undergo perfect combustion in gas. The combustibility, so to speak, of sulphur, may be said to be greater than any other of the constituents of gas. It probably is burned first into sulphurous acid.

The next class of substances are the odorous compounds. These pass chiefly into the tar in all cases. If the gas be scrubbed with water, after it is evolved from the retorts, as it is by the Metropolitan Gas-Light Company, more tar is deposited, and my observations have convinced me that I may say that these odorous compounds are condensed at that stage of the operation. Inferring from the well-known fact that woollen substances have great power to condense these odorous materials—these persistent odorous substances which are found in smoke, say, for instance, tobacco smoke—inferring from this that an instructive experiment might very readily be made, I took a blanket shawl which I have here, and which any one will see at a glance is very appropriate for the purpose, and spread it out in the fumes from one of the fouled purifiers of the Metropolitan Gas Company, which had been opened, and was giving off this stench very perceptibly. This shawl I carried with me and wore it a part of the time afterward, and tried to distinguish at intervals the odor which I supposed would be absorbed. I could not recognize any such odor in the course of, to the best of my recollection, about three hours afterward. I do not mention this as a conclusive test. It is only a very imperfect test. I judge from it, however, that there is much less of this intensely-odorous substance evolved from these lime-purifiers, when the gas has previously been scrubbed by water, as is practised by the Metropolitan Gas-Light Company; for the reason that, on previous occasions, when I have been exposed to the effluvia from open lime-purifiers, or even from that which generally floats from the atmosphere of a purifying-house to some extent, I have retained the smell about me for twenty-four hours, as near as I can recollect. These were instances where the gas had not been previously scrubbed with water. In previously scrubbing, the impurities had been condensed and did not reach the lime. I may say that I was surprised by the result, because I expected in this instance to carry the smell with me. I supposed this shawl was a peculiarly favorable fabric to absorb and retain it. I should conscientiously add that I have heard that the New York Gas-Light Company also scrub their gas as it comes from the retorts. I should like to ask Prof. Chandler whether he knows this is a fact or not?

Prof. Chandler: I believe I do.

Prof. Wurtz: And this would account for the comparative absence of these concentrated odorous substances, when the iron-oxide purifiers are open, and account for the discrepancy between the statements made by experts here, with regard to the comparative absence of these foul odors from the effete oxide of iron of the New York Gas-Light Company, and the opposite published statements made by English authors, Dr. Bowditch and Dr. Letheby, for instance. This, however, has no bearing upon the question as between the oxide-of-iron and the hydrate-of-lime process. This is a question apart. It has, however, a bearing upon the accusations that have been made against the Metropolitan Gas-Light Company, for not exercising due diligence, and not taking due precautions, to avoid offending the noses of the public. The gas itself is another material, given off when the purifiers are opened in both cases. This contains carbonic oxide, a dangerous and well-known violent poison. I have not found that it is pretended, however, by any one, that the carbonic oxide, given off from open purifiers, has ever produced any injury to any one. The supposition is simply absurd, from the fact that it is instantly diffused radially, and that its toxical efficiency must decrease, as the

light from a candle decreases, for instance, by radiating from the centre, so that at a very short distance it becomes so diffused and so diluted, that no chemist could detect it in the atmosphere any longer. With regard to sulphide of ammonium, I would suggest that the same remark applies; that the dilution of the material, in diffusing through the atmosphere, must increase as the square of the distance, not simply as the distance; consequently, in a very great geometrical ratio. This was shown by the experiment, the results of which have been already exhibited; in the specimens of lead-paper, seventy-five feet from the purifying house, when the purifier was in full process of oxidation. From a freshly-open purifier, at the distance of seventy-five feet, the delicate test lead-paper no longer detected sulphur in the atmosphere. The question between the lime and the iron process seems, to me, to narrow itself down, as between the alleged nauseating effects of sulphide of ammonium, and the admitted irritating and suffocating effects of sulphurous acid, although in minute quantities. Those who have tested these two materials here, will be able each to form his own judgment upon these two points. I am willing to admit the nausea, though with me the effect is exactly the opposite. Tobacco smoke, for example, is said to produce both effects—the nauseating and the stimulating—upon different persons, and also upon the same person at different times, I believe. Yet, it is scarcely proceeded against as a nuisance dangerous to health, unless inflicted to an excessive degree. Yet a word or two more with regard to sulphide of ammonium, before I leave it. It may not disappear simply by diffusion. The chemical books might be extensively quoted from, to show that it is an admitted fact that sulphide of ammonium oxidates in the air, forming hyposulphite of ammonia. I have in my notes references to Gmelin's Hand-book, supporting this statement, but, as I am confining myself to the sanitary points, I shall not present chemical references. I wish to remark here, however, that this would assist the process of diffusion, in actually destroying the sulphide of ammonium very rapidly, but I wish more particularly to point out that in the open atmosphere there is ozone, which very quickly destroys sulphide of ammonium. In the confined space of a room there is no ozone. Here is an important point which has not been considered by many of the chemical experts who have written upon this subject. This same remark might apply to the disappearance of sulphuretted hydrogen, if it were set free from the fouled purifiers when opened. But I should regard that question as having been fully disposed of, it having been fully conceded that the effluvia from the effete lime contains an excess of ammonia, and no free sulphuretted hydrogen, and I have also presented myself evidence, drawn from the iron process itself, that no free sulphuretted hydrogen can be present, as such, which would be absorbed with certainty by the oxide of iron, according to any principle that I am acquainted with.

The main point remaining, with regard to the sanitary bearing, relates to the nature of sulphurous acid. I must admit, in giving conscientious evidence, that I differ somewhat from many chemists of my acquaintance, on the poisonous power of sulphurous acid. I believe that it is underestimated. I believe that there is a class of men who are constitutionally insensible to the usual effects of sulphurous acid upon the mucous membrane of the air-passages. Individually I am an example, and I believe, in common with a great majority of mankind, of extreme sensitiveness to the action of the most minute quantities of sulphurous acid in the air. There are proofs, however, on record of the poisonous nature of sulphurous acid in very minute quantities, which can be cited. I am referring for instance to the frequent and protracted cases of litigation, particularly in European countries, concerning the effluvia given out by metallurgical furnaces, copper furnaces, particularly, the deleterious effects of which spread for miles around. I found that even with this radial diffusion and this decreasing inversely as the square of the distance, of the quantity in the atmosphere, yet sulphurous acid is still detrimental. In conversation it has been remarked to me that I overlooked, in taking this view, the presence of arsenic sometimes in these effluvia. I did not overlook it. Arsenic is given off in the form of arsenious acid, which is not a gaseous substance. It is a solid substance, which is very quickly deposited and cannot diffuse itself to a distance of miles. Yet there is abundant evidence on record of the diffusion of this actually poisonous influence, both upon plants and animals, about those furnaces where sulphuretted ores are burned—are roasted—to the distance of several miles. In one place, a

nobleman's park in Great Britain was entirely destroyed, root, leaf, and branch. These facts must be explainable. I explain them in this way. Sulphurous acid is what is called a cumulative poison, in the language of toxicologists. It is absorbed by water—by moisture and moist surfaces, with gradual accumulation upon such surfaces. It is absorbed by rain, and deposited upon moist surfaces. In this manner it destroys the leaves of plants, doubtless. It is converted into sulphuric acid by oxidation, to some extent at least, slowly—probably very quickly in the open atmosphere, by the action of ozone. I am verging upon the chemical points, so that I will not pursue this further. I think I have said sufficient to illustrate my views upon that head. My belief is that the use by the last generation so universally of brimstone matches, has given rise to a dangerous indifference to the inhalation of sulphurous acid in small quantities, and that the next generation will recognize the view I have taken of the question, that it is one of the most toxical gases, even in small quantities, to whose attacks human beings are liable in ordinary life. I would add that I am told that the French laws have prohibited the evolution of sulphurous acid from the smelting furnaces into the atmosphere at all, in consequence of their recognition of the poisonous character of this gas. In the pamphlet, which I have presented in evidence, the effects of sulphurous acid when set free in a confined space like a room, for instance, are alluded to, in the case of the Metropolitan Underground Railway in London, in which it is averred on good medical authority—the authority of medical experts called in the trials which took place—that the sulphurous acid was the cause of the deaths that have occurred, and, in the course of this trial, Dr. Letheby asserted as the results of his experiments, that one part of sulphurous acid in 100,000 of air is perceptible to the taste and will produce coughing. Dr. Odling, in one of his earlier statements on this subject, presented some views which have been cited here, to which I strongly object in many ways. The article which I allude to has been cited in the *New York Times* of February 12th.

Q. The extract from Dr. Odling's lecture? A. Yes, sir.

Q. Very well, what do you say about that, professor? A. Dr. Odling makes a calculation here, which I have not critically examined, but he presents the point that the fact that the sulphurous acid produced is diluted, with a thousand times its volume of carbonic acid, it is liable to render it less poisonous. Dr. Odling has overlooked the view that I have presented of the cumulative character of sulphurous acid as a poison; and taking that into consideration I would regard its dilution with carbonic acid merely as calculated to intensify its toxical action and make matters worse. The depressing effect of carbonic acid upon the system is well known, and if you add sulphurous acid, with the irritating effects of the sulphurous acid upon the air-passages, you have a combination of circumstances very unfavorable to health. There is no doubt that in the upper portions, as Prof. Silliman has already stated, of crowded assembly rooms, where gas is burned extensively, such as theatres, churches, ball-rooms even, and many other similar places, these injurious gases produced from the gas-burners would exist in much larger proportion than Dr. Odling admits here. That is another point which he does not take into consideration. His supposition, that the amount of ammonia ordinarily existing in the atmosphere can neutralize 20 grains of sulphur in the gas, strikes me as simply absurd. I have calculated that, for neutralizing 20 grains of sulphur, if converting it into sulphate of ammonia is a neutralization, it would require 21 grains of ammonia. Every chemist, who knows that an ordinary atmosphere contains an amount of ammonia almost infinitesimal, will see the unreasonableness of Dr. Odling's suggestion here. One hundred cubic feet of gas containing 20 grains of sulphur—or 45 as Prof. Chandler has stated, I think, was contained in the New York Gas-Light Company's gas purified by the oxide of iron—100 cubic feet of such gas would require very nearly 50 grains of ammonia to convert its sulphur into sulphate, or sulphite, of ammonia.

Q. I want you to state in as few words as you can the inefficiency of the oxide-of-iron process of purification in eliminating these contaminations, and the efficiency of the lime process in eliminating them—briefly, and as it is affected by this question of sulphurous acid of which you have been speaking. I wish a practical application made of what you have said there of the poisonous character of sulphurous acid, and how it is affected by those two systems of purification, or how the two systems of purification bear upon it? A. It is in

evidence from the researches of chemists that bisulphide of carbon, as well as the sulphide of ammonium and other sulphuretted compounds detectable by lead-paper, should be completely absorbed by hydrate of lime. There is no direct evidence that oxide of iron can absorb all the sulphide of carbon.

Q. Now then, the bisulphide of carbon and the sulphide of ammonium being left in the gas, after it has been subjected to the action of the oxide of iron, where and under what circumstances do other injurious effects present themselves? A. When the gas is burned, according to the experience of all mankind.

Q. When the gas is burned in dwelling-houses or public places, the presence of these contaminations is then experienced in the form of what? A. Sulphurous and sulphuric acid; the weight of evidence is so great on that point as to make the facts notorious.

Q. And which are destructive to property? A. Destructive to property, irritating to the air-passages of most persons, and peculiarly so in crowded places, and especially in the upper portions of the atmosphere of such crowded places.

Q. Now then, what kind of gas would you call that to be which exhibits the presence in it of from 21 to 45 grains of sulphur per 100 cubic feet? A. I should regard such gas as objectionable; I should prefer such gas as was purified down to 20 grains, or as low as possible; down to 10 or 12 grains, as the Manhattan Gas-Light Company, for example, claim to purify their gas.

Q. I will ask you the question whether you consider the emanations and exhalations from the spent lime, when the purifiers are open, as deleterious to health? A. I cannot view them in any light which will justify such an estimation of them; I am not aware of the slightest evidence which would justify any such view.

Q. Now then, you have been present at the New York Gas-Works—you have been at the New York Gas-Works where the oxide-of-iron process of purification prevails? A. I have, sir.

Q. Have you been there when the purifiers were opened and the foul iron was exposed to the air? A. I have.

Q. Will you state, if you please, whether they gave forth any odor, and, if so, what was the character of them? A. I perceived the characteristic odorous substances, which have been the subject of complaint, but not to so great an extent as I have perceived them on other occasions about large gas-works.

Q. Are they not inevitable—the presence of unpleasant odors when the purifying material, whatever it may be, as far as your experience extends? A. I have seen purifiers opened at large gas-works—

Q. I mean such as you have spoken of? A. I have seen purifiers opened in large gas works when these odors were so slight that they might be called imperceptible.

Q. What gas-works was that? A. In the Manhattan Gas-Works.

Q. That is where this new system of ventilation, of which you have spoken, prevails? A. Where the effete lime was thoroughly ventilated by the passage of the air through the closed purifier, and the mass converted into a porous substance something like chalk and inodorous; a specimen of it has been produced here.

Q. You have visited the works of the Metropolitan Company? A. I have on several occasions.

Q. I wish you would state your general conclusion as to the managment, manipulation, and products of the Metropolitan Gas-Light Company? A. I have made several visits. One of them was on the 30th of January, 1869, when a fouled purifier was opened especially for me at 10.30 in the morning. This purifier was 20 feet by 20, and with six tiers of trays. It contained between 200 and 250 bushels of lime, and very nearly 1,000,000 feet of gas had been put through this lime during the 24 hours immediately previous; atmosphere of purifying-house strongly ammoniacal and distinctly stimulating.

Cassidy, the foreman, stated that he had been six years in this purifying-house, and seventeen years in all in the same employment, having come from the Manhattan Works; was 56 years old, appeared robust and with healthy and florid complexion; stated that the men under him were all strong and uniformly healthy, but suffered from temporary irritation of the eyes

from the strongly ammoniacal atmosphere when the boxes were being emptied; gas not over-purified, as it still indicated small traces of sulphur and ammonia.

I would remark, that I ascertained on that occasion that the time of cleaning these large purifiers was about one hour, which is a very short period, if I am not mistaken, and indicates diligence in getting their material out of the way as much as it can be. I collected some samples upon that occasion which have already been exhibited here. Subsequently I made a visit, together with Prof. Silliman, on which we made those important tests with lead-papers, and made a thorough examination of the works. I agree with Prof. Silliman in the general conclusion that the management of the Metropolitan Gas-Works is quite as careful and cleanly as is compatible with the working of so large an establishment. Excepting this one point, which might be excepted, relating to the ventilation of the lime in the purifiers, which I regard as entirely extraneous to this question, a general answer would be that the management and manipulation of the Metropolitan Gas-Works is as careful and as cleanly as that of any other large gas-works which I have visited.

Witness: I would ask the counsel whether he wishes the question to relate to the future course—whether he wishes to ask my opinion as an expert as to what should be the future course of the Metropolitan Gas-Light Company.

Judge Van Vorst: No; that is not in relation to this question.

Q. You have stated that the oxide of iron has no affinity for, and does not remove the, bisulphide of carbon, is that so; what would be the effect of subjecting the gas, after the oxide of iron had acted upon it, to the hydrate of lime or wet lime; what effect would that have upon it; what office would that agent perform, and how would it affect the gas to be delivered? A. It would depend upon the quality of the gas; it would depend upon the richness of the gas.

Q. What effect would it have upon the illuminating power of the gas? A. It would decrease the illuminating power of the gas inevitably; it would amount to over-purification, technically so called by gas managers.

Q. And over-purification has a deleterious effect upon the gas, has it not? A. Upon the illuminating power of the gas.

Q. Then there is such a thing as over-purification of the gas? A. There is.

Q. And that would be the effect of subjecting the gas to this double method of purification of the iron and lime afterward? A. It would.

Q. Now, Prof. Wurtz, I desire to ask you, as an expert, your opinion as to the suggestion that has been made to substitute the use of the oxide of iron for lime by the Metropolitan Companies as a method of purification? A. I think it is incumbent upon gas chemists and upon the whole community to be taught by past experience in deciding such questions; we are now repeating a chapter of history here—a chapter of history which has been passed through by the gas manufacturers of Great Britain more particularly, and even to some extent by our largest company—The Manhattan Gas-Light Company. Complaints relating to this so-called nuisance, from municipal authorities, have been abundant in all civilized countries where large cities are lighted by gas. In England this was carried to such an extent that the gas companies were brought up so often as nuisances before the police courts, that they adopted the use of the oxide of iron, thinking that in that way they would get rid of a portion of the smell, and make matters better. The tendency, however, at the present time, is to go back again. The first result was that the amount of sulphur increased in the gas. I wish to add here, with regard to bisulphide of carbon, that it is considered by gas chemists as a very slippery thing. The same coal from the same heap varies very greatly in its product of bisulphide of carbon; sometimes the quantity being so very great that it is stated the gas will give off the smell of brimstone matches. The point which I wish to bring forward is, that bisulphide of carbon may occur in gas occasionally to a very large extent, owing to causes as yet unknown. Sometimes a coal which is found by analysis to be comparatively free from sulphur will give a very sulphuretted gas, from which the sulphur cannot readily be removed by the ordinary modes of purification. Until we know more about bisulphide of carbon, I think I would be cautious in substituting for the agent—the hydrate of lime, which is known to absorb it—any other agent which is not known to absorb it.

I wish to make one or two further remarks. I have already spoken of the danger also of oxide of iron catching fire, which seems to be spoken of as one not yet entirely mastered by our gas chemists.

Q. Is there a danger to be apprehended from the oxide of iron catching fire? A. Where a vast mass of it is used, as would be in a large gas-works like the Metropolitan and is kept lying about, I should regard it as a danger which must be taken into consideration in advance of any extended or continued series of experiments upon the subject.

Q. What is its liability to take fire attributable to—to the presence of what in the iron do you attribute that? A. To the presence of sulphuret of iron or sulphide of iron. The effects of its taking fire is to give off large quantities of sulphurous acid, which would render the atmosphere of the neighborhood of the works intolerable.

Q. That would be the effect of it? A. Yes, sir; with regard to the management of the Metropolitan Works, there is another point I find that I noted down in reference to statements that have been brought forward, which I believe are rather ancient, being taken from Ure, of men having been suffocated in sewers, wells, and pits, and so on, by the emanations from waste lime. I would simply remark that the only reasonable inference to be drawn from this is, that waste lime should not be used in that way to fill up such places; that it should be managed precisely in the way that the Metropolitan Gas-Light Company do manage it. It should be spread out in the open air so as to become ventilated and oxidized, and the sulphur compounds destroyed, so that they cannot collect together in depressions and cause danger and produce deaths in that way.

Q. I ask you whether you observed in the neighborhood of the Metropolitan Gas-Works any causes which would be likely to produce contaminating or deleterious odors. A. On the occasion of one of my visits I smelled a very putrid odor, which I was informed proceeded from an establishment for the boiling up of the carcasses of dead horses, the location of which was pointed out to me, and from which the wind at that time blew directly, as I observed.

Q. Where was that establishment? A. At the foot of Thirty-eighth Street, three blocks south.

Q. Was it such an odor as would be likely to proceed from such a cause as that? A. I should have said I perceived it on two occasions. On one occasion Prof. Silliman was with me, and he pointed it out to me, and we both remarked its entire distinctness from the odor of the gas-works. The wind was blowing in such a direction that no smell could come from the gas-works.

Q. Was it an odor that would be deleterious to health? A. I should think it was an odor decidedly deleterious to health. There is another large establishment that is known by the name of a piggery. I did not go inside of it, but I infer also from the odor, which was the usual odor of a pigsty.

Q. How near? A. Next door to the Metropolitan Gas-Works.

Q. It extended how far? A. It extended nearly the whole of the long side of the block between Eleventh and Twelfth Avenues. I wish to add that I have consulted some of my chemical friends about this question as to the character of these odors, which are known to spread through the city on certain occasions, and I have found several who have concurred with me in the idea that they were not always from the gas-works; that there are odors which spread over New York from other sources, and which they recognize as such—sometimes as the smell of putrid matter. I think the gas-works have received the blame of all these things. Injustice has been done them to that extent. I would add: I believe it comes under the present head that we are talking of, that there would be considerable difficulty and injury in at once arbitrarily changing the system in use by the Metropolitan Gas-Works at this season. It could only be done at a season when the consumption of gas is at a minimum.

Q. What season is that? A. In the spring, I suppose; in April.

Q. Have you stated already when the process of ventilation of effete lime in use by the Manhattan Company was first made known to the public? A. It was first really made known to the chemical public by its publication in the London *Journal of Gas-Lighting* during the last month—the preceding month of January.

Q. Of this year? A. Of this year. It has really not been made known to the general public in such a form as to be available practically at all.

Q. There have been no specifications of it published? A. There have been no specifications.

Cross-examined by *Mr. Bliss:*

Q. In your opinion, is there any necessity for the Metropolitan Gas Company to conduct its operations of the manufacture of gas in a way that gives off the offensive odors that are given off when its purifiers are changed? A. Not permanently.

Q. Had they, on the 14th of July last, or the 15th of July last, gone to work to remedy the offensiveness, could it not have been done long before this time? A. Well, I am not really bound to answer a question which relates more especially to gas engineering. I do not feel competent to answer. The impression on my mind is, that they might have done it. It is merely an impression; that is, if they had the specifications before them.

Q. Is not the process of purification by ventilation a modification of Palmer's process, which has been known for a long time? A. I should say not. It is an improvement—an additional improvement or appendage to the Palmer process, and throws out, also, some portions of the Palmer process.

Q. Is it a patented process? A. I do not know whether it is or not. I have no right to know any thing about that.

Q. Is there any difficulty in any other gas company gaining the means necessary to put that process in operation—I mean by inspection there? A. There is no difficulty in their gaining a knowledge, I presume. I know of no such difficulty. The Manhattan Gas-Light Company have offered no obstacles to inspection, so far as I am aware, although I am not familiar with their police regulations; but, as to their being able to do it, that depends upon conditions that I am totally ignorant of.

Q. What conditions? A. That was answered in my previous answer—as to whether it is patented, or is going to be, or is caveated.

Q. Suppose the chemist of the company goes there to-morrow, can he get access to the information necessary to put this process in operation? A. I cannot answer that question. I have no authority to answer for the Manhattan Gas Company.

Q. Then, if there are no means, to your knowledge, of putting that process in operation, we will leave that out of the question? A. I do not know that I am to decide as to whether we will throw that out of the question or not.

Q. How long has that process been in operation in the Manhattan Company? A. I am not familiar with the history of it, except in a very general way, and by hearsay. I have been informed that, in its present form, it has been in use some two or three years.

Q. At the Manhattan Works? A. Yes, sir. In a form somewhat approximating to what it is now. I am told it has been longer in use, but I could not give the details. The Manhattan Company has made many experiments. They have tried the iron process very extensively, and failed to succeed with it.

Q. That I do not want to go into. I confine myself to one class of questions at a time. Has not the ventilating process, as applicable to the additional purification of gas, been known to gas engineers for a long time? A. It has been known, but unfavorably.

Q. And no favorable process known until this was got out? A. Not that I have heard of. There have been dangerous accidents frequently from the attempts.

Q. Which of the processes, now in use in this city, of manufacturing gas is, in your opinion, the least offensive? A. I can have no hesitation in saying the process in use by the Manhattan Gas-Light Company.

Q. Which is the next? A. I am not familiar with the process used by the Harlem Company.

Q. I confine myself to the Metropolitan, New York, and Manhattan. The Manhattan is the best, you have said. Now, which is the next, in the sense of being the least offensive? A. To whom?

Q. The least offensive in the process of manufacturing. This order expressly says, or it speaks, of the process of manufacturing. It looks to that. A. I cannot answer the ques

tion. I have never made but two visits to the New York Gas-Light Company when they were opening the purifiers, and I cannot speak from so little experience and observation.

Q. If you cannot speak as to that, how could you speak so in your pamphlet, and in your testimony, as to the merits of these processes—of the New York Gas Company's process? A. Simply because I observed the facts stated in the pamphlet. I observed an offensive smell.

Q. But you did not observe sufficient to enable you to say whether that process was more offensive than the Metropolitan Gas Company's process? A. I will make an answer to this point—which, I presume, ought to be satisfactory—that, on the occasion on which I visited them for this special purpose, the New York Gas-Light Company's works, and the Metropolitan Gas-Light Company's works, on these special occasions, I observed a worse smell at the Metropolitan Gas-Works than I did at the other, as far as smell is concerned.

Q. And all your knowledge as to the matters connected with the iron process, you derived from what knowledge you obtained at those two visits? A. I cannot say that.

Q. Have you had any more opportunity of ascertaining the effect of the New York Company's process than you have had as to the question of its offensiveness? A. As has been remarked here before, there are many iron processes.

Q. I am talking of the New York Gas Company's iron process. Have you had any more opportunity? A. Not of that special modification; I have not.

Q. In changing from the lime process to the iron process, is any thing more needed than only changing the purifiers, and removing the trays and putting in iron instead of lime? A. That is strictly a question for an engineer to decide. The difficulties met with would, probably, be more in the collateral and subsidiary arrangements or fixtures necessary than in the mere cleaning out of the lime and putting in iron.

Q. What fixtures do you refer to? A. As I stated before, I am not specially familiar with the New York Gas Company's process. I have seen their material spread out on the floor of their purifying-house and in the open air, but I cannot state how much space they require to spread it out.

Q. I am talking about the space they require for revivifying. Suppose they desired to change to the iron process, would they need any thing more when the purifiers were changed than to take out the trays and put in iron instead of lime? A. I should regard that merely as a question to be decided by reference as to the facts of what the New York Company did under the circumstances—the modifications of their machinery.

Q. Is that the fact that that was all the change they made? A. I could not say whether the New York Company made any change in their fixtures.

Q. Then, any thing you have said as to the impossibility of the Metropolitan Company's changing to the iron process, you do not know, as a fact, whether they can or cannot, nor as to the time it would take. A. So far as the mere substitution of the iron for lime is concerned, I could not.

Q. Accepting the fact that the iron can be substituted for the lime, what other thing is there involved in the change, which will take time. Is there any thing more than a sufficient space for the revivification of the iron? A. In answering that question the most prominent point that comes to my mind is as to whether they would be able to command trained workmen, familiar with the iron process.

Q. Does it require any trained workmen? A. I should think it extremely probable it did. My experience is to the effect that no modification, in any great manufacturing operation, however small, can be carried on, however simple, without trained workmen.

Q. Do you not know, as an actual fact, that at the New York Gas-Works the men are not trained? A. In the peculiar process relative to the iron—I do not speak of mere laborers, I mean the men who are relied upon to see to it—the responsible men who are competent to meet any unlooked-for contingency.

Q. Do you not know that the parties controlling the process in use at the New York Gas-Works have made an offer to furnish all the assistance necessary to introduce that process elsewhere? A. It may be so, but I have not encountered the information.

Q. Have you not seen their circular? A. I have not, that I remember. I have not read it.

Q. Are not all the processes used in this city by the three large companies for the manufacture of gas, unhealthy? A. I should regard the iron process as having a tendency to affect the public health injuriously.

Q. In what way? A. By leaving the sulphur in the gas.

Q. You mean by introducing it into the rooms? A. Yes, sir.

Q. Now, taking that iron process and applying lime to it subsequently, would it then remain unhealthy? A. Probably not, it would only affect the eyes of the public.

Q. The effect would be deleterious to the illuminating power of the gas, would it not? A. I should apprehend that it would.

Q. Then, if the companies were required to introduce that ventilating process of lime, after the iron, and were required to furnish, for a given sum of money, the same illuminating powers, the only deleterious effect would be upon the stockholders, would it not? A. That is scarcely a question for a chemist.

Q. Unpleasant odors are not unavoidable in the practical manufacture of gas? A. It has been recently so discovered by the Manhattan Gas-Light Company.

Q. And that by the process which has been in use two or three years? A. Secretly; that is, it has not been a matter of publicity.

Q. Has there been any difficulty in any way, so far as you know, of gaining access? A. Not so far as I know. I have found the doors open.

Q. Why did you say secretly? A. Secretly may be too strong a term. I mean privately—it has not been a matter of publicity.

Q. Have all of the gas companies and yourself known all about it? A. I think not, from the fact that I have talked with officials of the gas companies, who, until quite recently, had not understood the nature of it.

Q. What officials do you refer to? A. That I do not think I should be called upon to say.

Q. Any officials of the Metropolitan Gas Company? A. No, sir. I could not specify any officials of the Metropolitan Company.

Q. Was or was there not any one of that company? A. I do not remember any especial individual.

Q. When were you consulted by the Metropolitan Company with reference to any question connected with their manufacture of gas? A. I could not remember the precise date. The president of the company called upon me first in connection with matter some time in August last, I believe.

Q. What then happened—was there any thing more than asking you to suggest something? A. The salient points of that interview which recur to my memory are, that the president desired me to recommend to him some gentlemen who would be competent to take up the investigation of gas purification, with a view to the improvement of their process.

Q. At that time you knew the Manhattan gas process was in operation? A. At that time, yes, sir. Previous to that I had been examining it.

Q. You satisfied yourself it was successful? A. I was not so strongly decided about it as I became afterward. I was making up my mind in that direction.

Q. After that time, when did you first do any thing further in connection with the Metropolitan Gas Company's process? A. Not until within a few weeks. I was not called upon until a few weeks since. I cannot remember the precise date at this moment.

Q. Have you not a personal knowledge of the iron process in use abroad? A. I have not, sir, from observation.

Q. You do not know how the New York Company's process bear comparison with them? A. Not from observation—no, sir.

Q. You heard Prof. Silliman's testimony? A. I was present at the whole of his testimony, I believe. I heard most of it—yes, sir.

Q. Is there any portion of it you disagree with? A. There may be some minor chemical points involved in which I did not agree with him. I have already alluded to one point—as to my estimation of the actual poisonous character of the sulphurous acid in small quantities.

Q. Is there any thing else that occurs to you? A. There were other points which I really cannot recollect at this moment.

Q. Any thing of any importance? A. Nothing of any essential importance bearing upon this question, that I recollect.

Q. You spoke of ozone in the atmosphere—is there any great quantity of ozone in the atmosphere of cities? A. It is very varying, as a general thing. It has been found in the atmosphere of cities constantly by tests applied.

Q. Is not its amount very much less than in country atmosphere? A. Its amount is small, but it is believed to be constantly present and constantly reproduced.

Q. Is it not much smaller than in the atmosphere of the country? A. I do not recall the facts distinctly enough at this moment. My impression is that it is so—that in cities it is usually smaller than in the country. That depends upon the proximity of the sea-coast, I think.

Q. Do you consider yourself a sanitarian? A. Only so far as I have had my attention drawn a good deal in the course of my studies, and in my practice; though to subjects rather connected with therapeutical subjects than sanitary.

Q. How as to physiological matters? A. I could scarcely call myself a thorough physiologist; toxicology I have studied pretty thoroughly—the science of poisons.

Q. Is not any thing injurious to health, in a greater or less degree, which changes the natural composition of the atmosphere we breathe? A. I do not know that I get the full sense of the question.

Q. Is not any thing which changes the composition of the atmosphere which we breathe dangerous to health in a greater or less degree? A. I should say the question was scarcely definite enough for me to answer yes or no.

Q. Is the healthiest atmosphere that which nature has made? A. That is decidedly the dictate of experience.

Q. If any change of any kind is made in that, does it not in a greater or less degree make it unhealthy? A. The atmosphere itself is variable somewhat.

Q. Can you answer my question or can you not? A. It is simply a question as to the degree of the change, and the kind of change. There are many changes that could be made, which would not affect the health appreciably or at all. Most atmospheres might even be changed for the better, as regards health.

Q. Now, the Manhattan Company's process—what change would it require to introduce that at the Metropolitan works? A. That is also a question which the engineers would have to answer. I could say, generally, that additional buildings would be required; and, I presume, an additional exhauster, or engine of some kind, for producing a current of air through the purifiers.

Q. What additional buildings? An additional building for the supplementary purifier at least.

Q. Any thing else? A. It would require an additional engine-house, and room for the exhauster. This additional building for purifying is nothing more than a brick building—perhaps twenty feet square. That is a very small matter. The engine and boiler would be the main thing—the engine for drawing the air through.

Q. Is that a matter requiring any great time? A. I believe it generally takes some time to set the boilers and erect an engine, and get them in working order.

Q. It is simply the time necessary to set a moderate-sized engine. A. I presume so, so far as I can say, not being an expert in that particular branch.

Q. You have spoken of over-purification, and of the effect of absorption of naphthaline; what is the effect of it?—any thing but to reduce the illuminating power. Is it any thing other than that? A. I don't know that it produces any other injurious effects.

Q. I understand you to say that, in your opinion, the New York Gas Company's process allows too much sulphur to pass into the rooms? A. That would seem to be the conclusion, not only from general experience in the iron process, but also from Prof. Chandler's direct investigation.

Q. You state, in your pamphlet, that "the Metropolitan Gas Companies have conse

quently been unable to comply with the conditions required by the Metropolitan Gas Act of 1860, that the gas shall not contain more than twenty grains of sulphur in 100 cubic feet." Speaking of the London companies, you consider the parliamentary requirement, reducing the sulphur to twenty grains in one hundred cubic feet, as reducing it to the point of health? A. I consider gas containing twenty grains of sulphur as still decidedly objectionable, if better can be done.

Q. Then you consider that the parliamentary limit of twenty grains, to which the London companies have been enabled to reduce it, as still leaving it unhealthy? A. Under circumstances favorable to the development of its detrimental effects, I should.

Q. Schultz is a competent chemist, is he not? A. In gas matters he is a very good chemist.

Q. Then, when he states that the New York Company's iron process has reduced it to 12.91 grains of sulphur in one hundred cubic feet of gas, you admit that is about one-half less than the English parliamentary limit? A. I should not attach so much importance one way or another to those figures given there, as to the quantity of sulphur. They are both, in my opinion, lower than is probably the truth—considerably lower.

Q. Then why do you say in your pamphlet, "The most striking fact, developed by the above short but significant report, is the high degree of freedom from sulphur of the gas of the Manhattan Company," if you did not believe it to be true? A. I spoke there of the report.

Q. Why did you, in a report to the company, quote another report which you did not believe to be true, and state "that that was exceedingly significant and satisfactory?" A. It would be rather strong language to say that I do not believe the report to be true. I believe it to have been low in all probability; the word believe is too strong a word to use in the connection, in my opinion.

Q. Do you believe that this report of Mr. Schultz is correct? A. I think in the main it is.

Q. Do you believe it to be correct in its statement of the sulphur in the gas of the New York and Manhattan Companies? A. I have no belief on the subject. I think it is not strictly correct.

Q. How long have you so thought? A. One important piece of information, which led to the modification of my opinion upon that subject, was Prof. Chandler's investigation.

Q. How long have you so thought it was not correct? A. Since I have myself been occupied with Prof. Silliman, within two months past, in some determinations of the sulphur in gas, which have led me to believe that some determinations of the sulphur heretofore made have been too low.

Q. Then, I understand you that you consider this report of Mr. Schultz, so far as it relates to the amount of sulphur, as valueless? A. Not altogether valueless.

Q. If incorrect is it not valueless? A. The results of Mr. Schultz and Dr. Torry were doubtless obtained by the method which has been in ordinary use by gas companies for determining the sulphur, and which was introduced by Dr. Letheby. Several other chemists have recently come forward with the opinion, within the last year, that all the determinations made by Dr. Letheby's apparatus are too low, and that the amount of sulphur is much higher than has been placed by him, showing that the amount of sulphur, as indicated by Dr. Letheby's method, is incorrect.

Q. It is the method which has been used in England for determining whether the companies there have conformed to the parliamentary standard? A. Yes, sir, and it is very seldom that it has given twenty grains, until quite recently.

Q. If, by a process which is used abroad to determine whether the gas comes up to the parliamentary standard, it is found that the oxide-of-iron process gives eight grains less of sulphur than the parliamentary standard requires, does it not show that that process is superior to the process in use in London? A. A great deal depends upon the coal that is used in making the gas. If very pure coal is used, free from sulphur, applying the same process of test abroad and here, we get eight grains less in the New York Company's process than is required by the parliamentary standard—between seven and eight grains.

Q. Taking that same test, does that not show that the iron process in use by the New York Company is, so far as sulphur is concerned, superior to the process in use abroad? A. It would simply show, to my mind, that it is probable that just at that particular time the New York Gas-Light Company were operating in some way; either by the aid of coal favorable to such a result, or by that combined with other means, of scrubbing, for instance, which they use, as I am told, so as to produce a gas very free from sulphur. I do not know that the oxide-of-iron process—I do not know that it would be right to attribute the whole result to that.

Q. Here is a test that is used abroad, which gives between seven and eight grains of sulphur less to one hundred cubic feet than the parliamentary standard requires. Now, it being stated by yourself that the companies in London cannot even come down to the parliamentary standard, does not that fact show that the process of the New York Gas Company furnishes a gas purer and more free from sulphur than that of the London companies? A. Speaking of the whole process of the New York Gas-Light Company, I should answer in the affirmative.

Q. I understand you to agree with Prof. Silliman in saying this; in so far as purposes of health are concerned, the question of naphthaline and phenol may be left out of this consideration? A. I consider them very minor matters.

Q. Do they have any bearing whatever other than the fact that phenol is a disinfectant? A. I should prefer to throw them out of this consideration. I think they bear about as much upon the one side as the other, in every aspect, both *pro* and *con*.

Q. Is not sulphide of ammonium found in gas purified by the Manhattan process? A I have not recently tested the gas of the Manhattan Company. So far as my own knowledge extends, they do not deliver gas containing sulphur.

Q. Was not the sulphide of ammonium found in the purified air, on being delivered from the supplementary purifier? A. It was, but in a very minute quantity. It was scarcely perceptible to the smell, though it was to lead-paper.

Q. You have used in your direct testimony, at various times, the words: "There is no evidence, that so and so occurs in or is accomplished by the iron process." What do you mean by that? Do you mean that you have not investigated it sufficiently to say that these things are accomplished, or what do you mean? A. There is more than one case of the kind, to which different answers would apply. There are cases in which, if I remember aright, I made use of that remark, in which the matter has been investigated.

Q. The expression is peculiar, "There is no evidence." A. I mean that we cannot proceed in chemical matters any more than in legal matters, without some evidence—without facts to start from.

Q. When you say that there is no evidence, that such and such things are eliminated by the iron process, do you mean that does not eliminate, or simply that you do not know that it is eliminated? A. I simple mean that no chemist has ever brought forward any evidence, from experiments, that it has been eliminated.

Q. Do you mean that no chemist has ever brought forward any evidence, that it has not been eliminated? A. In some cases I do. In the case, for instance, of the bisulphide of carbon, some chemists have made very extensive experiments with bisulphide of carbon. They have found compounds of bisulphide of carbon with lime, but they found none with oxide of iron that I could find any evidence of.

Q. Do you know whether they looked for any? A. No, sir; I cannot say that.

Q. Did they say that they found none, or simply failed to mention them? A. If they had found them they would have mentioned them.

Q. Do all gas companies apply the scrubbing process. Is it in use by all companies? A. No, sir; not by all.

Q. Is it in use by all the companies in this city? A. I think the Manhattan Gas-Light Company do not scrub their gas before condensing it.

Q. In speaking of the hydrosulphuric acid and hydrosulphate of ammonia in your pamphlet, you say that "in the lime process the conditions present themselves merely for the arrest of all the free carbonic and hydrosulphuric acids, and free ammonia salts, in definite forms of combination. In the case of the iron process this can by no means be asserted."

Q. Do you mean to say, by that, it is not true of the iron process? A. No, sir; I mean that the weight of evidence is very much against it in the case of the iron process—the testimony of facts and investigations, so far as they have gone.

Q. In speaking under the head of carbolic and cresylic alcohols at its close, you refer to the advantage of the lime, and then say, "which, however beneficial under peculiar circumstances, cannot be regarded as, by any means, indispensable and desirable as a compulsory infliction upon consumers of gas." What do you mean by "peculiar circumstances?" A. I mean in case there are bad smells or an infectious atmosphere. Carbolic acid or phenol might then be even beneficial, but that, under ordinary circumstances, the delivery of gas containing creosote and like substances would be objectionable in private houses. I should class phenol—however, I believe we have concluded that phenol is a matter of such minor importance, that it might as well be thrown out of consideration.

Q. On page 13, you make a quotation from the last edition of Clegg, and then one from Bowditch, and say that you are inclined to agree with Mr. Bowditch. I understand that to be your present view? A. The first paragraph, although taken from the edition of 1866, is very likely a copy taken from the previous edition.

Q. Then, I understand the view you there express to be the views you now entertain? A. Do you refer to the passage commencing, "I am constrained?"

Q. Yes, sir. A. I still have that opinion.

Q. If you are of the opinion that there is still a worse smell at the Metropolitan Company's works, when they change their purifiers, than at the New York Company's process, what opinion do you entertain then of the Metropolitan Company's process? A. I stated at the very outset of my examination, I am confident, if my recollection serves me, that there was a bad smell given out by the Metropolitan works.

Q. The point is here. You make a quotation, in which you say, "The vapors of the hydrocarbons are much heavier than the atmosphere, and, when evolved from the foul oxide of iron by the heat of chemical action, they float in the lower stratum of the atmosphere, near the surface of the earth, and produce extensive nuisances. There are few smells more offensive to many persons than the smell of these compounds given off by the oxide in the process of revivification, and in every gas-works. They ought to be consumed instead of being allowed to escape. If this be not done voluntarily, the law ought to compel it." Then you say, "I am constrained to state that my own observation, so far as the natural capacities of my mind and senses extend, bears out the positive assertions of the Rev. Mr. Bowditch in the latter paragraph." Having stated that, and having stated further here, that the smell from the Metropolitan Gas Company's works is more than that from the New York, what, in your opinion, should be done with the smells given off by the Metropolitan Company's works? You said they ought to be burned up in the other case? A. They should most certainly be prevented by the best means which offer to accomplish that result, because they are unpleasant to the public. I should state, however—I certainly ought to be allowed to recall—that when I stated there was a worse smell at the Metropolitan Company's, I spoke of the works, and not of the neighborhood, at a greater or less distance from the works; because I should say precisely the opposite with regard to that. At a little distance from the New York works, I perceived a bad smell, and across the street from the Metropolitan works I perceived a very slight smell.

Q. Do I understand you to say that the smell from the Metropolitan Company's works is not perceptible at a distance from the works? A. I have not succeeded in perceiving it at a distance of about one block from the works—I mean the offensive stench. I have not happened, it may be a mere accident, to catch the very offensive stench which has been spoken of.

Q. You say on page 15, "as regards the peculiar unknown substance which diffuses itself from the purifiers when opened." To what purifiers do you refer? A. I was then speaking generally of the ordinary dry-lime process of purification, without any assistance from other devices.

Q. You are still of the opinion that that odor has a resemblance to, or belongs to, the class of sickening odors, and is developed and intensified by aërial dilution? A. I have perceived such odors.

Q. Are you still of the opinion expressed in that passage? A. In connection with my last reply, I am.

Q. How do you account for the fact that it is intensified by atmospheric or aërial dilution? How do you account for the fact that you smell it at the works and do not smell it across the street? A. I did not smell it at the Metropolitan Gas-Works, as I have said in my direct evidence. I have tried to catch some of it in a shawl and could not get any of it.

Q. You smelled some of that class of smells? A. No, sir. The smell at the Metropolitan Gas-Works was a different smell from that referred to. I did not perceive any of this smell at the Metropolitan Gas-Works at the time I visited them.

Q. Then you did not smell, at the Metropolitan Gas-Works, the peculiar unknown substance which diffuses itself from the fouled purifiers when opened? A. Certainly not so much as I have perceived, for example, about a building, the roof of which was having coal-tar put upon it.

Q. Then, if you did not perceive peculiar odors which came from fouled purifiers, to what odors did you refer when speaking of the smell as being offensive? A. In the Metropolitan Gas-Works?

Q. Yes, sir. A. I referred to the smell of sulphide of ammonium, which was perceptible in the purifying-house, and to a certain distance around it.

Q. Did you perceive any other offensive smell than that of sulphide of ammonium? A. I perceived the smell of naphthaline, which is rather pleasant to me.

Q. Did you perceive any offensive odor from the purifiers? A. I have already stated that I perceived an odor which was usually classed as offensive.

Q. But it was not the odor you referred to on page 15? A. I did not recognize it as such. I attempted to account for that in my direct evidence by attributing it to the scrubbing of the gas—the copious quantity of cool water which has taken off all these offensive materials, in all probability, to the tar-well.

Q. Have you ever heard of the oxide-of-iron process catching fire? A. It is spoken of frequently in books. I have not had it under my personal observation.

Q. Do the books say that it has caught fire, or that there is danger of it? A. They say that it has caught fire, I believe.

Q. At this time that you went to the Metropolitan Gas Company and did not perceive these odors from the purifiers—was your arrival there expected, were you there by appointment? A. On my first visit, when the purifier was opened, it was expected; but I am not aware whether it was or not on the visit which I made with Prof. Silliman. I do not think it was expected, certainly the time was not set.

Q. What is your opinion as to the proper future of the Metropolitan Gas Company as to its process of manufacturing? A. It was answered in great detail by me, to the best of my recollection, in my direct testimony. I gave my opinion as an expert that the Metropolitan Gas Company should be guided by the past experience of other companies—by the past history of this controversy, as it has taken place already.

Q. Is it not your opinion that they ought to put the process in use which is used at the Manhattan Company's works? A. I do not feel as if it were a proper question to ask me on this occasion. I have no objection to reply to it, if it is insisted upon. I do not look upon myself as called upon here as an expert to advise the engineers of the Metropolitan Company as to their duty.

Q. You are here as an expert. I will put it another way. Is it your opinion that, out of consideration to the public convenience—leaving health out of the way—a gas company, having its works situated as the Metropolitan Company's are, should introduce the Manhattan Company's process? A. So far as my knowledge of gas purification extends, I should think, if I am required to give an answer to that question, I should answer in the affirmative.

Q. Aside from all theoretical considerations, is it not a fact that the gas companies in nearly all the large cities in Europe have been compelled by the sanitary authorities to so modify their process of manufacturing as to prevent the dissemination of the offensive gases,

which are still liberated by the Metropolitan Company from their fouled lime? A. My general reading of gas literature permits me to answer that, in large cities and densely-populated neighborhoods, they have.

Q. In other words, your answer is in the affirmative? A. It is in the affirmative, I believe, if I understand the question distinctly.

Q. Is the *American Gas-Light Journal* a recognized authority? A. It is the only authority in the shape of a journal in this country upon gas matters.

Q. In the number for February 16th, 1869, the article under the heading of the "War of the Purifications;" when did you first see that article? A. Is it necessary to be very precise about the time; I don't know that I can recollect it aright.

Q. Give it as precisely as you can? A. I think I saw it there on Wednesday or Thursday last.

Q. After its publication? A. That question I shall decline to answer; I do not think I am called upon to give the authorship of an article in a paper; it is attributed to the editor of the paper.

Q. Did you write the article? A. (*By advice of Judge Van Vorst.*) I wrote the article.

Q. Does it express your opinion? A. Well, so far as any opinion is expressed in it, it does.

Q. Does it state correctly your position? A. Not my individual position; it states the position of the journal.

Q. But it does not state your individual position? A. I did not feel called upon then, nor do I feel called upon now, to state my individual position in the case.

Redirect examination by *Judge Van Vorst:*

Q. Do I understand you to say, in answer to the question of Colonel Bliss, that in your opinion the Metropolitan Gas Company would do well to adopt the process of ventilation in use by the Manhattan Company? A. It would, in my opinion, be well for them to thoroughly examine into the process used by the Manhattan Company, and adopt it in some form of modification. I do not look upon it as a perfect thing by any means yet. No process is perfect; they might be able to improve upon it.

By *Mr. Bliss:*

Q. It is the most perfect you know of, is it not? A. It is, as I said in my examination.

Adjourned to Wednesday, February 24th, at one o'clock.

TESTIMONY OF OSCAR ZOLLICOFFER, PRESIDENT OF THE METROPOLITAN GAS-LIGHT COMPANY.

SATURDAY, *February* 27, 1869.

Oscar Zollicoffer, called for the Metropolitan Gas-Light Company, being duly sworn, testified as follows:

Examined by *Judge Van Vorst:*

Q. You are the President of the Metropolitan Gas-Light Company? A. Yes, sir.

Q. How long has that company been in operation? A. Five and a half years.

Q. What district do you light? A. From 34th to 79th streets, between North and East rivers.

Q. You used the lime process for the purification of gas? A. Yes, sir; at present dry lime.

Q. Was that process in use throughout the city when your company went into operation? A. There was none other than that; it is only lately that we knew of another process.

Q. What, if any, preparations or efforts have your company made to remove the effete lime after it has purified the gas—state what you have recently done on that subject? A. I have engaged boats, as I promised Dr. Chandler six months ago; when the material is placed on the boats, the hatches are closed without any delay, and then it is removed over to New Jersey, where we have engaged dumping-grounds.

Q. That is to say, as soon as the purifiers are opened, the lime is removed to those boats lying at your dock? A. Yes, sir.

Q. And the hatches are closed on the lime immediately? A. Yes, sir.

Q. And that you mean to continue? A. Yes, sir, until another method is found out for purification.

Q. Has your company any preference for the dry-lime process of purification, if there is a better process than that? A. Not in the least; I told Dr. Chandler that very thing; we want the very best, whether it is lime or oxide of iron; we want that which is the best for the purification of the gas, and at the same time which will retain its illuminating power.

Q. The object of the company is to obtain the best gas, and also to have the best illuminating power? A. Yes, sir, we would like to improve upon any method.

Q. Since this proceeding has been pending before the Board of Health, what have you done about ascertaining the process of purification in use in Europe? A. We sent out a special man that was recommended to us very highly, from two well-known chemists, to ascertain the different modes of purification in use there; he has just returned.

Q. What did you send him to Europe for? A. To ascertain the modes in use in England, in France, in Germany, to see what improvements could be made, and with the intention to immediately adopt that which, from the different reports he should make, should be the best, after its being submitted to the Board of Health, if acceptable to them; I proposed to Dr. Chandler, as soon as it is in operation, that he shall come and see it on the premises; if it had not been for the press of business, we could have had it in operation by the first of March; the spent lime is all going to be removed; it is now being removed, a large quantity being taken each day; there is no smell to that lime.

Q. You are having that removed all the time? A. Yes, sir; we want the room ourselves.

Q. You say that your time is engrossed, in extending your works? A. Yes, sir, in extending our works and making improvements and repairs, we occasionally need very much this year.

Q. Has there been any special pressure on your company this year? A. Yes, sir, particularly so; from the increase of the consumption of gas in the district; we must build more retorts and gas-holders this year.

Q. Your works have been tested to their utmost capacity? A. Yes, sir, to the utmost in December and January; to the utmost they could produce.

Q. What, if any steps, has the company taken lately, for the purpose of introducing any improved method for the purification of your gas? A. As I said before, we engaged a chemist, and sent him to Europe.

Q. Has your Board appointed a committee to introduce an improvement immediately? A. They have; they made me chairman, and appointed three members to take it particularly in charge.

Q. With instructions to introduce immediately some improved system of purification? A. Yes, sir.

Q. So as to avoid all offensiveness? A. Particularly to avoid all bad smell; I forgot to say we had a chemist who has been making experiments, and has several times destroyed the bad smell in small quantities of the effete lime, and he believes he can do it on a large scale.

Q. That is, remove the foul odors from the spent lime? A. Yes, sir.

Q. And you think those experiments you will be able to report on Monday? A. We will begin to work by it on a large scale, we think, on Monday and every day next week; the lime will be put into the liquid to destroy this smell; it is an experiment only, and I can't say it is perfect only on a small scale; next week all the spent lime is to be treated according to this new process.

Q. Which is the result of some recent experiments of this chemist you have spoken of? A. It is a wonderful success on a small scale; the sulphur is taken out and is crystallized.

Q. Is your company, in good faith, now engaged in the work of so purifying the gas as to get rid of all offensive odors? A. Yes, sir.

Q. Colonel Hastings is under the impression that you are pursuing the Fabian policy? A. No, sir.

Q. Your Board has no preference for your present system of purification over any better system? A. No, sir; on the contrary, I prefer the other one; I heard of it in Europe, and I told our engineers repeatedly that it was my view, and I am certainly in favor of it.

Q. You would be glad if the process of purification by oxide of iron should prove to be

a good process, and if so, your company would have no objection to adopting it? A. No, sir, they would not have any objection.

Q. What should you think of adding a little lime to the oxide-of-iron purification? A. That is my impression; I am not competent to speak upon that subject, but I think it will be adopted again in English works.

Q. You think they will supplement the iron process with the lime? A. Yes, sir, with one larger.

Q. Would you think that would have any effect upon the candle-power of the gas? A. Chemists say so and our engineer; we have got a chemist who has discovered what I think will no doubt be an improvement; I can't give the name, as it might interfere with our arrangements.

Q. Have you ever seen this process which is in use by the Manhattan Company? A. Yes, sir; it is just the same as ours; I have seen the retort—exhauster—where it passes through; Dr. Chandler told me he was not satisfied with that, that it was only carrying it from one place to another.

Cross-examined by *Colonel Hastings:*

Q. Is there any other company in the city that is using the dry-lime process in the same manner as it is used by the Metropolitan Company? A. I think the Manhattan has recently adopted theirs—the ventilation.

Q. Do you not regard the process as used by your company as the most offensive of any now in use in this city? A. Allow me to say that I cannot say any thing of that kind; the odors arising from our gas-works in our neighborhood are not offensive; we have four blocks round from which no complaints have come; Dr. Stone told me that in two years only two complaints had been made.

Q. During the process of the purification of the effete lime at the Metropolitan Works, is not a strong and pervading stench produced? A. Immediately when you open the purifier, but not longer than for half an hour afterward.

Q. Does not that stench extend a great distance from the works? A. Not two blocks; we are different from the Manhattan Company, in that they do a large business, while we do a comparatively small business; I would like to have gentlemen come and see our works.

Q. Do you mean to say that the odors from this effete lime do not extend beyond two blocks? A. Except perhaps in very damp weather, for a day or two.

Q. How long have you known of the improvement now in use at the Manhattan Gas-Works? A. I should think about eighteen months.

Q. Do you know any reason why your company could not adopt a similar improvement? A. Because we do not think it is sufficient.

Q. Do you know any reason why your company could not adopt the same improvements? A. I think it is not quite sufficient. I don't think it would be satisfactory to the Board of Health.

Q. Do you know any reason aside from that why your company might not adopt it? A. Except that we are very crowded for room. It is a sliding ground there, and it is very difficult to make a high tower.

Q. Your company could obtain the room for that purpose? A. Far off; not near by.

Q. Do you know any reason why your company could not adopt the method of purification in use at the New York works? A. That is because it has not been proved a success. Mr. Adams, the president of the company, told me about three or four months ago, when I was there in August. He said, "Mr. Zollicoffer, do not adopt it. Every day the gas changes; one day it is good and one day it is poor. The gas is not uniform.". You can examine him and he will tell you the same.

Q. When was this committee for introducing a change appointed? A. That was only at the last meeting—Wednesday of last week.

Q. Were they invested with full powers? A. Yes, sir.

Q. With full powers to make the improvements? A. Yes, sir.

Q. This is the first decided step taken by your company for the introduction of a change? A. No, sir; we have given you already what has been passed by the Board.

Q. But no committee was appointed? A. No, sir; it was left with the president and officers of the company at that time.

Q. And beyond sending an agent to Europe and the recent experiments you have spoken of, nothing has taken place with reference to a change since this investigation commenced? A. Have been all the time reading and studying.

Q. No other experiments? A. No; we hadn't the time to spare.

Q. When was this chemist employed to report on a better process? A. It was in September or October when he went to Europe.

Q. What is his name? A. Schussler; he resides in this city.

Q. You say that the process recommended by him is to be introduced at the works? A. No, sir; that is another one.

Q. When was the chemist employed, who is about to recommend a new process to your company? A. It is about three weeks ago first.

Q. Who is he? A. Mr. Milachon; it is a French name.

Q. The experiments made by him are with direct reference to deodorizing the effete lime? A. Yes, sir.

Q. Is the process upon which he is experimenting to be introduced into your works? A. If it proves to be good it will be. I will not introduce any thing permanently, except I first consult with Dr. Chandler.

Q. Have any number of experiments been made upon that process in your works? A. Yes, sir; several times last week.

Q. And those experiments are about to be extended? A. Yes, sir; this week largely—on Monday, if all the boxes are ready. We have to get all the apparatus made.

Q. Have boxes been ordered sufficient for the entire amount of effete lime? A. What is made fresh.

Q. Fresh effete lime? A. Yes, sir.

By *Judge Van Vorst:*

Q. As the boxes are emptied? A. One is emptied at a time every second day.

By *Colonel Hastings:*

Q. There is a considerable quantity of effete lime which has been removed from the Metropolitan purifiers now lying in an exposed state in this city? A. Yes, sir.

Q. There is over 100,000 bushels? A. I should say by this not much more, that is the spent, has no bad smell at all.

Q. During the process of removing the effete lime from the Metropolitan purifiers, as now conducted, is it not exposed to the surrounding air. A. Not more than five minutes—just the transportation to the boat.

Q. When did you adopt this improvement of shipping the lime? A. About five days ago the boats came up.

Q. To what point was it removed? A. Over to Bull's Ferry.

By *Judge Van Vorst:*

Q. Would you suggest the oxide-of-iron process supplementing that of lime? A. That is what I believed would be the result. We wish to give the best gas, and manufacture with the least offence to the public.

By *Colonel Hastings:*

Q. How much time is required for the transfer of the refuse lime from the purifying-boxes of the Metropolitan Works to the vessel? A. Five minutes.

Q. The entire contents? A. I should say two hours at the most—less than two hours.

RESOLUTIONS OF THE BOARD OF DIRECTORS OF THE METROPOLITAN GAS-LIGHT COMPANY.

Judge Van Vorst put in evidence the resolutions passed at the meeting of the Board of Directors of the Metropolitan Gas-Light Company, on the 24th of February, marked Exhibit D.

(EXHIBIT D.)

At a meeting of the Board of Directors of the Metropolitan Gas-Light Company, held at the city of New York, on the 24th day of February, 1869, the following resolutions were passed:

Resolved, That it is, and always was, the sense of this Board, that the process of the manufacture and purification of gas in use by this company should be such as to avoid all just ground of complaint on the part of the Board of Health, or of any citizen of New York, referring to a memorial presented by this Board to the Board of Health, August 17, 1868.

Resolved, That a committee of three members of this Board be appointed with authority and power to put in operation, as soon as can be done, a judicious system of purification, which shall be an improvement on the company's present method.

That, in carrying out this resolution, such committee are empowered to adopt such improved system of purification as will prove satisfactory, and to apply the same at the company's works as soon as it can be done.

Resolved, That, in considering such improvement, the committee be governed by the two principal objects, to give the best and purest quality of gas to consumers, and manufactured and purified in such manner, under the most recent and best methods, and so as to be attended with the least possible offence or annoyance to the public.

Resolved, That a copy of these resolutions be transmitted to the Board of Health.

Resolved, That Thomas T. Buckley, David H. McAlpin, and Robert H. Arkenburgh, constitute such committee.

Attest—WM. MEIKLEHAM, Secretary.

TESTIMONY OF JESSE LISSENDEN, AN ENGINEER AT THE MANHATTAN GAS-WORKS.

Jesse Lissenden, called by the Board of Health, being duly sworn, testified as follows.

Examined by *Colonel Hastings:*

Q. You are an engineer of the Manhattan Gas Company, of this city, are you not? A. At that company. Not of the company.

Q. Of the works? A. Yes, sir.

Q. How long have you been employed in that capacity? A. Nearly fifteen years.

Q. And during this time you have been familiar with the method of purifying gas—in use at the Manhattan Gas-Works? A. Yes, sir.

Q. What is the process used by the company you represent? A. I suppose it is called the dry-lime process.

Q. In what respect does it differ from the process employed at the Metropolitan Works? A. I don't know that it differs at all.

Q. Is the method of ventilating the refuse lime different from that in use at the Metropolitan Works? A. I don't know any thing about the Metropolitan Works.

Q. What is your method of ventilating the effete lime? A. By oxidizing the foul gas that remains in the lime after the purification.

Q. State how this is done. A. The cover is first raised from the box and shifted one side.

Q. From the purifying-box? A. Yes, sir. Then the exhauster is applied underneath the bottom of the box for two hours. The exhauster runs, I think, about 800 revolutions a minute.

Q. Runs by steam? A. Runs by steam, yes, sir. After that, the men go to work and take out the first tier of plates, which makes an opening right to the bottom of the box, on each side, that allows the air to go down underneath, giving free vent right through. After it has worked in that way for one hour it is closed off. We then run the exhauster another hour with an opening in the engine-room sufficient to let the fresh air go through the engine-room, through the deodorizer, and out of the chimney where all the foul gas escapes. This is supposed to put out all that is not taken out by the deodorizer.

Q. The gas that remains? A. Yes, sir; after three purifiers have been applied, the material in the deodorizer is changed. We never put more than three through it, without supplying it with fresh material.

Q. After the effete lime has been through the process you have described, is it inodorous? A. I can't say.

Q. What is your opinion? Is it offensive to smell? A. I should think not; no, sir. I could not say positively, for I have never taken particular pains to smell of it. Of course it can't be expected that it will be made as pure as pure air by any process that can be devised.

Q. Why was this change you have spoken of introduced? A. Because there were so many complaints around.

Q. Do you find in practice the improvements you have described successful? A. I believe it gives general satisfaction.

Q. Does it meet the end for which it was designed? A. I think it does.

Q. Since its adoption, have there been any complaints in regard to the offensiveness of the refuse lime at your works? A. Well, sir, I have heard some of the bosses complain of it in the works. The men sometimes say that something is not working right.

By *Judge Van Vorst:*

Q. Complain of a bad smell? A. They say so.

By *Colonel Hastings:*

Q. Have there been any complaints from the neighborhood in regard to the offensiveness of the foul lime since the adoption of this improvement? A. I don't know that there have; not that I remember.

Q. The only complaints that have reached your knowledge are from the employees in the works? A. Yes, sir. There are various causes, you know, for their finding fault with the smell since the adoption of this new improvement. For instance, if the exhauster, instead of running 800 revolutions, is run no more than 400, or 500, you could not expect it to produce the same result as when it runs 800; but, if the belt slips, we have to stop and take it up, Probably we may run on one purifier only before we detect that the belt has slipped and the exhauster is not making the revolutions that it should do. Then, of course, there would not be the amount of suction on that purifier, and the smell would probably be a little bad.

Q. During the process of deodorization, as conducted at your works, can offensive gases or odors be detected outside the works? A. Yes, sir, but very seldom. As this gentleman before me stated, in foggy weather, you may find a little smell.

Q. In works now using the dry-lime process, what changes would be necessary to introduce the improvement used by the Manhattan Company? A. I don't know. State that again.

Q. In works now using the dry-lime process, as ordinarily conducted, what changes would be necessary to introduce the improvement used by the Manhattan Company? A. They would need to have a suction-pipe attached to every box in the house—the bottom of it—and then they would need to have an exhauster as we have, and then they want another box in a small building by itself, and a chimney connecting with this box.

Q. Do these changes involve any interruption in the manufacture of gas? A. They need not do so.

Q. Is any additional room required for the use of this improvement? A. Oh yes.

Q. How much? A. The exhauster would take five or six feet square.

Q. Is that all the additional room required? A. That is all that part would require.

Q. Then there is the steam-engine. What further room would that require? A. It requires ground enough to build the house for a deodorizer and chimney.

Q. About how much? A. I suppose that building, as near as I can guess, is 20 feet square, or probably more. It might be 25; I could not say positively. Then the chimney, which is 60 feet high, that would require some space.

Q. Do you regard the introduction of this improvement by any company, using the dry-lime process, as entirely practicable? A. Yes, sir, if they have got the space to put the machinery, and the chimney, and the house on. I forgot to tell you that there is another article attached to that deodorizer—a water concern. That is a new thing which has been put in there within, I can't tell you positively how long a time, but I should think inside of fifteen months.

Q. Scrubber? A. A kind of washer—something of that kind. I have not seen it. I have been told it was there.

Cross-examined by *Judge Van Vorst:*

Q. About how long would it take to make all these erections? You speak of the chimney; putting up the engine. About how long? A. You have become too tight upon me.

Q. How long would it take your company to do it? A. I could not say.

Q. Could you say about how long? A. No, sir; I could not come within three or four months of it. I would not like to say any thing about it.

Q. Do you think engines could be ordered and all those buildings be put up within three or four months? A. Provided they had men enough.

Q. It could be done? A. It could be done in four months, I think.

Q. All these improvements made? A. Every thing.

Q. I want to ask you this question—whether there is any part of your improvement in use by the Manhattan Company, for ventilating the effete lime, or the deodorization of it, which is subject to a patent? A. Yes, sir.

Q. Who owns the patent? A. The architect of our works. His name is Farmer.

Q. You say that there is some unpleasant smell about the works? A. Occasionally.

Q. Do you know of any method of the manufacture or ventilation of gas, except there would be some smell about it? A. I do not.

Q. The object of your company has been so to purify it as to have the least possible smell? A. Yes, sir.

Q. When this system of ventilation you spoke about is in use, there is on some occasions an unpleasant smell? A. Yes, sir.

Q. Especially as I understand you to say when the air is moist and heavy it drives the odors which come out of that chimney down to the earth? A. I suppose so.

Q. And at times the bosses about your establishment have complained of smells—about smells? A. Yes, sir.

By *Colonel Hastings:*

Q. You say Mr. Farmer has a patent? A. Mr. Farmer has a patent on the exhauster.

Q. The method of purification is the same in use as at the Metropolitan Company, except in the matter of ventilation? A. I suppose so, I have not been there.

Q. The only difference is the supplementary process of ventilating of the effete lime? A. Yes, sir.

Q. Your company has not the exclusive right to use any portion of the machinery you describe? A. Not that I know of.

By *Judge Van Vorst:*

Q. Do you think they have not? A. I know there has been one manufactured and put up outside of our works in the city. I think it was for a different purpose—for blowing fires.

Q. The question which Colonel Hastings asked you, and which I should like to have you answer, was this: Whether the patent is owned by the Manhattan Company? A. It is owned by this man, Farmer. The company have nothing to do with it that I know of.

Q. Do you know what other companies in this city use the dry-lime process, except the Metropolitan and the Manhattan. How does the Harlem purify? A. I don't know.

By *Colonel Hastings:*

Q. Are you familiar with the oxide-of-iron process? A. I am not.

Q. So far as you know, your company is perfectly willing that other companies should adopt the improved system of ventilating lime? A. So far as I know.

TESTIMONY OF PETER CARTWRIGHT, AN ENGINEER AT THE NEW YORK GAS-LIGHT COMPANY'S WORKS.

Peter Cartwright, called by the Board of Health, being duly sworn, testified as follows:

Examined by *Colonel Hastings.*

Q. Are you in the employ of the New York Gas Company? A. I am.

Q. In what capacity? A. As practical engineer.

Q. How long have you been so employed? A. For twenty years.

Q. What process of purifying gas is in use by that company? A. The iron process.

Q. State in what form the iron is used in that process? A. The iron-ore we get from Staten Island, and with it is placed a percentage of iron borings and turnings, and we mix the mass with ammoniacal liquor to oxidize and prepare it for use.

Q. How long has this process been used in your company? A. Ten months.

Q. What process was in use by your company previous to this process? A. Dry lime.

Q. What changes were necessary in the introduction of the present process? A. Well, very little changes indeed—introducing new bottom, with skids of wood.

Q. New bottoms to the purifying-boxes? A. Yes, sir; that is the superficial bottom to receive the iron oxide.

Q. How much time would be required to make this change in any gas-works using the dry-lime process? A. About five hours, in the putting in the new bottom, and be ready to turn on again when the lime was fouled. That is the way we turned on ours.

Q. If a gas company using the dry-lime process had a double set of purifiers, would this change to the iron process involve any interruption in the manufacture of gas? A. Not at all; with only one set it would not.

Q. How does the iron process as used by your company compare with the dry-lime process in respect to offensiveness? A. Our house is now like a bed of roses to what it was when we used lime.

Q. Your company found the dry lime very offensive? A. Yes, sir; very, indeed.

Q. And was it that cause that led them to the adoption of the iron process? A. It was, and to comply with the law.

Q. Is the iron process used by your company practically inoffensive? A. There is no offensiveness whatever about it.

Q. Does the gas manufactured by your company suffer in illuminating power in the use of this method? A. I don't know, to my knowledge. Some say it does, and some say it does not.

Q. Do you know how your company regard the iron process; whether as a success or a failure? A. They consider it a success.

Q. Do you know whether they have any intention of modifying or changing the process they now use? A. I do not.

Q. How does the process used by your company compare with the dry-lime process in respect to expensiveness? A. There is great economy in the iron process. I think it will save our company this year $13,000 in lime alone—material alone. The labor is not so much, because of the offensiveness of the lime in winter, when we were making our greatest consumption. We had to employ a double set of men sometimes, and men would be knocked over, and then we would have to employ men in their places and pay them, too. I have picked them up and carried them out myself.

Q. When you were using the dry-lime process? A. Yes, sir.

Q. Knocked down by what? A. The offensive smell.

Q. How many instances of this character do you recollect? A. I could not tell how many, there have been so many. I have picked them up myself and carried them out. One day the lime-man was bringing in a load of lime, and the man was going over when our men caught him, or else he would have gone over and the horse and cart would have gone on to him. The horse fell down, and we had to take him out of the harness and take him out in a lot.

Q. Men and horses were afflicted in the way you describe, when the lime was being removed from the purifying-boxes? A. We had broken into them then for ventilation, and the fumes starting out of the house met them. We had to let them stand for four or five hours before we could get the lime out.

Q. Is any additional room required for the use of the iron process? No; we made no additional room. It would be better with additional room, certainly, or else in a shed or out-building.

Q. Can the oxide of iron be revivified in the open air, or do you require a building for that purpose? A. It can be revivified in the open air, but it is better if you could protect it in storms. Of course it is better if it is protected from the weather.

Q. Is any odor given off from this iron mixture during the process of revivification? A. Not at all.

Cross-examined by *Judge Van Vorst:*

Q. How long has this process of purification by your company been used? A. For ten months.

Q. Before that, you used dry lime? A. We did.

Q. How long have you been an engineer there? A. Twenty years.

Q. And were you an engineer during the time they used dry lime? A. I was.

Q. Is any of the process of this purification by the oxide of iron patented? Have you got a patent for it? A. We have.

Q. From whom did you get the patent? A. From the parties at Washington.

Q. Who owns the patent? A. Me, for one.

Q. Do your company? A. Me, for one.

Q. You are interested in the patent? A. I am.

Q. And you think well of that process? A. Yes, sir.

Q. There is no smell of gas from the fouled iron? A. There is not.

Q. It is pleasant, on the other hand? A. Yes, sir, I think so.

Q. Does it deliver as pure gas as the gas purified by the lime process? A. I don't know of my own knowledge.

Q. Does it take out the carbonic acid? A. In a great measure, it does. In a small measure, it might not.

Q. Does the presence of carbonic acid increase or diminish the candle-power? A. I should think it diminishes it a little.

Q. Then the gas delivered purified by the oxide of iron has not so great an illuminating power as that which is purified by the lime process? A. I think it would if the lime and the iron process was carried the same distance. I think the iron process would retain its luminosity for a greater distance than the lime process.

Q. Do you mean to say that? A. I do.

Q. I ask you this question: Does the iron process take out all the carbonic acid? A. No, sir.

Q. Therefore, it does not purify quite so well as the lime in that respect? A. No.

Q. In respect to taking out carbonic acid, the iron process does not take it out as well as the dry lime? A. It does not.

Q. In order to get this right to purify with the oxide of iron we must get the right from you, must we not? A. For what?

Q. We must obtain the right to use it from your patent? A. Certainly.

Q. From you? A. Certainly.

Q. You say you never heard any complaint made about bad smells since the oxide of was used there from anybody? A. From anybody.

Q. Have you heard no complaint about the gas delivered? A. I have seen it in the press.

Q. What have you seen in the press about it? A. Why, saying that the gas burned blue, etc.

Q. That the gas burned blue, etc.? A. Yes, sir; I did not see that, but I saw the words of Prof. Wurtz here, who made use of those words. I did not see it in the press myself before that.

Q. Haven't you heard complaints made of that gas, that its candle-power was diminished? A. I have.

Q. You have heard those complaints? A. I have.

Q. That the candle-power of the gas purified by the oxide of iron was diminished? A. I have heard so.

Q. Repeatedly? A. Yes, sir.

Q. From consumers? A. Never. Not a word from consumers.

Q. From whom? A. From opponents of the oxide-of-iron process.

Q. From those who were opposed to the purification by the oxide-of-iron process you have heard that the candle-power was diminished. A. Yes, sir.

Q. Don't you yourself think it is diminished a little? A. I do not.

Q. Don't you think the candle-power is diminished some? A. I do not.

Q. Not at all? A. I do not.

Q. Not in the least degree? A. I do not, to my knowledge.

Q. After the iron is taken out of the purifiers, what do you do with the foul oxide of iron? A. Throw it out on the floor.

Q. For what purpose? A. To oxidize it.

Q. Is there nothing given out; are there no emanations proceeding from it? A. No smell.

Q. Are there no emanations proceeding from it? A. Yes, sir.

Q. There must be some emanations? A. Yes, sir; there is a vapor rises from it when in the state of oxidation.

Q. There must be room of course to have this iron after you have taken it out of the purifiers, to ventilate it? A. Certainly, must have room, of course.

Q. Do you know how the Harlem Company purifies its gas? A. I do not, from my own knowledge; I heard that they purified with lime, that is all I know about it.

Q. Dry lime? A. I have heard so.

Q. Have they got any ventilator? A. I don't know.

Q. Are you taking measures to introduce your patent throughout the country—this process of purifying gas by iron? A. Will serve anybody who will take it.

Q. Are you or are you not taking measures to introduce it? A. We are not.

Q. You are doing nothing about it? A. We never apply to anybody, or to Mr. Zollicoffer, nor any other parties around New York.

Q. Have you advertised it? A. We have.

Q. You are doing it now? A. We are not.

Q. You have advertised it lately, have you not? A. I should think not for four or five months.

Q. You have advertised the sale of the right to use it? A. Certainly.

Q. And you are doing it now? A. Yes, sir.

Q. To any person who wishes to buy it? A. Yes, sir.

Redirect examination by *Colonel Hastings:*

Q. How came you to make the invention spoken of? A. We tried to comply with the law and to destroy the offensive odors around the works.

Q. You were making experiments to that end? A. Yes, sir.

Q. Relating to the removal of the offensiveness by the old process? A. Yes, sir.

Q. Under what auspices were you making such experiments; under whose directions or request were you making those experiments? A. The request of the president of the Company.

Q. Of the New York Company? A. Yes, sir, Mr. Adam.

Q. Were those experiments satisfactory to the Company? A. They were glad to get hold of it.

Q. And for that reason the process was introduced in the New York Works? A. Yes, sir.

Q. By whose advice, if any, did you obtain a patent upon the process? A. No one's advice; only we advised each other; two of us were associated, William H. St. John, and Peter Cartwright.

Q. You obtained a patent, I suppose, because you required it, as a valuable improvement and a success? A. Yes, sir.

Q. Has the New York Company any interest in the patent? A. Not a cent.

TESTIMONY OF ELISHA HARRIS, M. D., SANITARY SUPERINTENDENT OF THE METROPOLITAN DISTRICT.

Elisha Harris, M. D., being called for the Board of Health, being duly sworn, testified as follows.

Examined by *Colonel Hastings:*

Q. State, if you please, your profession and residence. A. I am a physician and reside in West 42d Street.

Q. How long have you been in that profession? A. For the last twenty years, sir.

Q. And in what professional relation are you at present employed? A. Sanitary Superintendent of the Metropolitan District.

Q. Have you read most of the testimony adduced in the hearing under the order relating o the Metropolitan Gas Company? A. I have read about two-thirds of all the testimony hat was given prior to your sitting to-day, from the first.

Q. In addition to the examination of the evidence referred to, have you given the subject of the best method of purifying gas any study or attention? A. Only so far as connected with the questions of sanitary improvement in cities, where these questions have been already examined, and in connection with the progress of chemical knowledge, as these questions illustrated some of the leading facts in the chemistry of gases.

Q. Do you know what gases, if any, are given out from the foul lime removed from the purifying-boxes of any company using the dry-lime process? A. The gases which are given out in such a manner as to be the object of special examination and remark by sanitary officers and physicians are mainly the sulphuretted gases and undefined and unestimated amounts of the compounds of cyanogen, but chiefly the sulphuretted gases, the sulphide of ammonium being evolved after a time when the fouled lime is exposed to the atmosphere.

Q. Are any of the gases escaping from such fouled lime recognized by sanitarians as injurious to life or detrimental to health? A. Yes, sir; all the compounds or complex sulphur gases, except sulphurous acid in vapor, which is not to be mentioned as a gas, are recognized as directly injurious to health, the sulphide of ammonium being the most poisonous of the sulphur gases which are known to sanitary science; the experiments with these different gases being too incomplete to enable us to compare them relatively, we can speak of the sulphuretted hydrogen and the sulphide of ammonium as being chiefly the obnoxious gases evolved from the foul lime when exposed to the atmosphere.

Q. What evidence is there that sulphuretted hydrogen gas is dangerous to health? A. First, the large number of accidents from respiring the gas have abundantly proved that it is fatal to life when it exists in a certain percentage in the common atmosphere, or in the atmosphere of any room or place; then a great variety of experiments with small animals which have been very decisive in their character; and thirdly, observations upon persons who are compelled, from their vocations or by any accident, to breathe sulphuretted hydrogen for any considerable period day after day in their vocations; all these go to prove the same thing, that the sulphuretted hydrogen is injurious to health, and the experiments prove that a small percentage will destroy life; a percentage, however, of one per cent. does not necessarlly destroy life, but whenever the percentage has been increased from point to point, in the scale, the various animals that have been subjected to it have been killed. The list of experiments given in this volume which I have in my hand—

Q. What volume is that? A. This is Hammond's Hygiene.

Q. Is it a standard work? A. Yes, sir; this is a brief list; and, if you desire, a more complete list of experiments could be presented immediately, but this briefly shows about how the case stands. I will read from page 156: "Sulphuretted hydrogen is exceedingly poisonous. Dupuy *père* found that 1-800th of this gas was sufficient to render the atmosphere so poisonous that small birds were killed in a few seconds when subjected to its influence. One part in 299 parts of atmospheric air proved fatal to a dog. Chaussier found that one part in 250 of air sufficed to kill a horse."

Hammond further says: "The results of my own experiments with sulphuretted hydrogen do not differ materially from those of other observers. I found with Dupuytren, that all small animals, as birds and mice, were killed by a smaller proportion of gas in the atmosphere in which they were confined, than larger animals. Sparrows and mice did very well in an atmosphere 1-1000th of which was sulphuretted hydrogen. With more than this death ensued, though not until twenty or thirty minutes had elapsed." These were carefully made by Dr. H., who is a distinguished physiological experimenter. He continues: "On a *post-mortem* examination the blood was found perfectly dissolved, and the blood-corpuscles completely broken down. The action of sulphuretted hydrogen, when not inhaled in a large quantity, appears to be that of a narcotic poison. Its effects upon the organism, when its action is long continued in a small amount, has not been so thoroughly investigated as is desirable. That it is capable of producing injurious results is very certain. * * * * Dr. Taylor, the author of a work on medical jurisprudence, refers to instances which occurred

as to the poisoning by this gas of workmen engaged in excavating the Thames Tunnel, by respiring the atmosphere of this place. The strongest fellows were in a few minutes rendered extremely weak, and several died."

All the evidence regarding the operation of the poison upon the blood being so very important, that sanitary officers have felt it necessary to ask for special experiments. A series of experiments on a large plan have been in progress for two years under the Health department of the Privy Council of Great Britain upon this and various allied subjects, and some of the results of these experiments have also been published, much more conclusive than these older and more general experiments.

Q. Well, do the conclusions established by those experiments all tend to the same end? A. They all show that these sulphuretted gases destroyed the blood-corpuscles, which have always been recognized as constituting the most essential element in the whole range of the physiological constitution of the living body. To know just what kind of changes occur in the blood, while circulating under and exposed to the influence of these gases, has been one of the nicest and most exact kinds of chemical inquiry that have ever been pursued.

Q. What other gases escaping from fouled gas-lime would you consider obnoxious to health? A. The sulphide of ammonium is the asphyxiating gas of all others, which is recognized as being the most quickly destructive to life, and it is combined in the gases which float off from the fouled lime, so that no ordinary observation, I suppose, could state which was in excess, but the special odor of sulphide of ammonium is far the most offensive. That is the gas that usually so quickly destroys life in persons who chance to go down into deep privy-vaults, as scavengers, and that class of persons who have suddenly died on going into privy-vaults—accidents that have actually occurred in this city, and which are recurring all over the world among scavengers.

Q. As a sanitarian, will you state what is your opinion as to the danger to the public health from the presence of the fouled gas-lime within the limits of the city of New York? A. If gas-lime is exposed to the atmosphere it will give off these deadly gases, and the sulphide of ammonium with certainty coming that is derived from the sulphide of calcium, which exists always in abundance in the fouled lime, and it will float in the common atmosphere until such transformations have occurred as destroy its character, as sulphide of ammonium will float in the direction in which the wind is blowing, which is a fact well certified to by experiments, and in particular states of the atmosphere as regards temperature and barometrical pressure it may float far over the city—so far as to become dangerous to health to a great distance. Again, the gas itself is judged to be more obnoxious at the distance of a few blocks from the mass of lime from which it is evolved, than it is immediately on the premises. My own observation fully confirms that as regards the effort to discover the localities within which this gas can be recognized by its odor, and effect upon the respiration. I have smelled it as far eastward as the top of Murray Hill on Madison Square, and as far southward as 14th Street, and frequently in West 42d Street, where I reside.

Q. Have you ever been able to trace these odors to their source? A. Yes, sir; I was able to trace these odors without being at the time able to gain access to the fouled pile of lime, some years ago, when the dry-lime method was used in the works on the east side of the city. I do not think that to be a demonstration which would answer any positive purpose of a public statement, but to me it was entirely conclusive. Following merely the odor, and noticing the direction of the wind at the time.

Q. To what distance did you then follow the odor? A. I then resided one door north of the Rev. Dr. Bellows's church.

Q. On what street? A. Between 20th and 21st Streets. I should think it must be a mile to the gas-works, perhaps three-quarters of a mile to the nearest gas-works, and I then made observations which satisfied me that the 14th Street works gave off the nuisance quite as abundantly as those that were near to my residence; and more recently, and last summer, when peculiar circumstances rendered it easy to follow any particular odor, from changes that had occurred in the atmosphere, making it peculiarly pure, and reducing the temperature by the change of the direction of the winds on the 5th day of July—I deemed it a duty to follow this kind of evidence up to its source, and asked one of the Sanitary Com-

missioners to join me, and in that case I was able to follow the odor directly to its source in the Metropolitan Gas-Works.

Q. From what point to what point? A. I observed the odor first at about 30th street, while walking up Broadway. On reaching my house in West 34th Street, between 5th and 6th Avenues, the odor was so oppressive in 34th Street, that I endeavored to follow from that point, and following from 34th Street, I went with the Sanitary Commissioner, who joined me for the purpose, to the lime-heaps, which were then freshly covered with the foul lime that had been thrown out. This observation was made for the purpose of satisfying our judgment on the precise source of a particular odor, and to see it with our eyes. There was then no intention of making it the ground of special complaint, because other companies in the city were known to be using the dry-lime process of purification, but here was an opportunity to settle unequivocally a fact which was important to know.

Q. You found the source at that time to be the heaps of fouled lime of the Metropolitan Gas-Works? A. Yes, sir, unequivocally.

Cross-examined by *Judge Van Vorst:*

Q. Have you given the subject of the purification of gas practically any attention? A. I have given it only that kind of attention practically which a person interested in sanitary knowledge must give if he would understand the source of impurity in the atmosphere, and the merits of questions which have become important in all great cities where gas manufacturers are located in the midst of the population. These questions are important in all the great cities of the world at present.

Q. You have given some attention to the subject of the merits of the respective methods of purification in use, theoretically, have you not? A. Yes, sir.

Q. Now, doctor, as the result of your own investigations, which is the better purifier of the gas—which eliminates from the gas the most foulness—the oxide-of-iron or the dry-lime method of purification? A. Neither process perfectly purifies the gas from what you technically denominate impurities?

Q. I ask you which of those two processes is the better purifier. I am not asking you whether any process does perfectly, but which of those two processes is the better purifier. A. I will answer your question directly and categorically as you put it, if you allow me to refer to substances instead of processes. For, as regards these two elements—natural elements—they are things and not processes. If taken alone, either process would be objectionable, but if I am to answer that question as relates to these things, I would say positively that lime will remove the largest amount of certain impurities, and hold those impurities ready to yield up again in another poisonous form, and iron will remove positively the same impurities, but not all of the same—the worst of the same—and will fix those impurities, and not yield them up in a poisonous form. So that, regarding them as processes, there is first that difference to be stated and that fact to be stated. Then we have to commence anew with the fact how to proceed to finish the task of purification.

Q. Could you suggest any improvement upon the process, or method, or thing, or what ever you call it, in use at the New York Company for the purification of its gas? A. I have not seen the New York process; I know those only by name.

Q. The oxide-of-iron process, which is the only process in this city covered by a patent; could you suggest any improvements in addition to the use of the oxide of iron as it is used there? A. I have not seen that, though I have been invited; I have been unable give any attention to either process, and, in my judgment, the oxide-of-iron process, as used there, has gradually diminished the offensiveness which people usually complain of in the neighborhood of gas-works, but I don't know the extent of the completeness in the purification of the gas itself.

Q. But the gas itself, as delivered to its consumers, is not as thoroughly purified of sulphurous compounds as that which would be delivered by the lime process; do you think so, speaking chemically and theoretically? A. There must be used, in addition to the iron process, however that is used, some alkaline earth, or substance, or fluid, that will receive and recombine certain impurities which the iron does not fully control.

Q. How would you suggest a little of the hydrate of lime as a supplement to it? A. hat is found, by experience, to finish the job well.

Q. If the hydrate of lime in a moist form is used and not over-used, the quality of the gas that is burned is of the very highest that is known among gas manufacturers? A. Such is the testimony of hygienists who have examined it, and no offensiveness is caused among the community in which the gas is made; but the hydrate of lime must be used after the iron process, or you will have the offensiveness, because the iron is used merely to fix certain things which are very difficult to control, viz., these sulphur compounds which go to form the sulphide of calcium, etc., in the lime process, but then here is the carbonic-acid gas which must be controlled in order to give the quality that is needed to the gas; there is a residuum of sulphur which needs to be withdrawn if possible; the experiment of withdrawing it by secondary purification, I believe, has resulted triumphantly in several instances.

Q. In order to put this thing in a practical form, oxide of iron does not thoroughly remove the carbonic acid, and there is still in the gas a residuum of sulphur, so I understand you to say? A. Certainly, sir.

Q. And which, if it was subject to a supplementary or subsequent process of purification by the hydrate of lime, you think it would remove that carbonic acid and the residuum of sulphur the iron had failed to take out? A. The supplementary process with lime properly presented to the gas for this second purification, is said to be entirely triumphant, and the gentlemen who have certified it have undertaken the inquiry so intelligently and so conscientiously for hygienic purposes, that I would like to present it as an item of evidence.

Q. I would like to ask this question, whether there is any danger by subjecting the gas to this subsequent action of the hydrate of lime, after the iron has acted upon it, of enfeebling the illuminating power of the gas? A. Of course there would be, unless the chemist was master of the situation and knew his trade.

Q. What effect does the presence of carbonic acid in the gas, which the oxide of iron fails to eliminate, have upon the illuminating power of the gas when combustion takes place generally? A. I must say that practically I could not answer that question, and I merely state it upon the authority of chemists. It is not necessary that I should commit to paper any of the evidence, as it would not be original. It is but a small item, and imperfect as my own chemical knowledge might be, I would undertake to get out the carbonic-acid gas without damaging the gas.

Q. Don't chemical writers say that the presence of carbonic acid in the gas, when combustion takes place, diminishes its candle-power; don't writers upon chemistry say that? A. They do, and display weakness on the spot when they say it, unless they show how that carbonic-acid gas can be withdrawn.

Q. You have suggested a way to get rid of that by the use of hydrate of lime supplementary; I call your attention to a process where the hydrate of lime is not used at all subsequently? A. I have answered the question.

By *Colonel Hastings:*

Q. Do you know of any authority recognized as such among sanitarians that discusses the question of these poisonous gases escaping from foul gas-lime upon the blood or health? A. I do.

Q. What? A. As I stated in the opening evidence upon the medical question, the blood does suffer directly when exposed to these gases. I wish now to state that sanitarians have undertaken to find how it suffers, and whether such poisons can be resisted, because it is es sential when studying the causes of diseases to find out what are inevitable poisons acting on the blood, and it turns out rather unexpectedly to some medical inquirers that there are gases which are in a very absolute sense poisonous. The carbonic-acid gas has long since been found to be only contingently poisonous. It destroys life; but it was not the poison which could always be asserted as the source of particular conditions of ill health which were discovered in foul places. What were the other gases was the question, and what kind of gases: and in this inquiry which is now in progress, and probably will be for several years by the Medical Department of the Privy Council of Great Britain, which is the last report of the second instalment of the chemical evidence on this very subject of the effect of certain exhalation, vapors, and gases upon the blood, on the subject of physiological and pathologi-

cal questions connected with these chemical and natural forces—this item of evidence occurs bearing directly upon the question you ask. The essential element of the blood-corpuscles, which is most prominent and unyielding to all other effects which disease produces, is the hematocrystalline that enters into the constitution of every blood-globule, and constitutes a large percentage of it. In that hematocrystalline is combined all the iron that floats in the blood. The hematocrystalline has become the subject of most careful study, with reference to the changes gases produce therein. Now it is found that carbonic-acid gas does not at once destroy hematocrystalline. It is found that most of the poisons that are introduced into the body will break up the blood-globules and still leave hematocrystalline to crystallize as hematoidine. We have had occasion to study the hematoidine in the investigation of last summer, and the history of its persistent life as an element in the fluids, even of sick animals, is an interesting fact. But certain gases act upon that hematocrystalline and eliminate it so that it cannot be constructed into any of the forms of life in the animal tissues. That destruction of a very persistent and important element therefore of the body comes to be a specially important fact in hygiene, for we have been hunting for years for methods of exact demonstration of hygenic questions, and now it is done at the expense of the Lords of the Privy Council in the class of studies on a large scale. I will read from the Tenth Report of the Medical Officer of the Privy Council, London, 1858, at page 170: "A diminution of hematocrystalline in the body costitutes the disease termed chlorosis or anæmia. It is either a specific element or a symptom and consequence of chronic disorders, or particularly tropical fevers. * * * The hematocrystalline is the last ingredient of the blood which undergoes putrefaction. Its stability is the main factor in the stability of life. This quality is perhaps mainly the result of the power which it possesses of taking up oxygen from the air, and yielding it again to other matter in contact. * * * * Hematocrystalline combines readily and more pertinaciously than with oxygen, with a number of these gases, such as carbonic oxide, sulphuretted and phosphuretted hydrogen. * * * * The hematocrystalline is the last ingredient of the blood which undergoes putrefaction. It preserves its color and spectrum for years, in a horrible offensive mixture."

Q. That kind of evidence has this value in answering this question which has just been asked—that it is reducing to demonstration what hitherto had been stated in the way of assertion? A. It is showing how a change occurs, and, in order to show how the highest resources of chemistry are brought into play, namely, spectrum analysis, and show the beginning and progress and ending of certain changes which occur when the blood is exposed to certain poisonous gases; and the result of this inquiry shows that certain gases and these complex sulphuretted gases, and the phosphuretted gases, and a large number of others, and compounds of cyanogen gas come into the same list, instead of merely dissolving and breaking up the blood-globules, actually destroy the chemical constituent which in most diseases fails to get destroyed; so that the sanitary fact begins to be settled as a demonstration that certain gases should not be permitted to be evolved in a great quantity into the atmosphere which people breathe. Not that the people will be immediately killed, but that their health will be silently and persistently injured from a cause which no science before had perfectly controlled. Now, chemistry comes in with its exact methods of demonstration, but not until these higher applications of it by the beautiful method of the spectrum analysis had enabled us to get down to the one thousandth part of a grain, and study it with the interest with which we could formerly study larger quantities.

By *Judge Van Vorst:*

Q. The effect, I suppose, would be the same if these poisonous gases were evolved in the dwelling-houses where combustion of the gas takes place? A. Oh, yes; it makes no difference where the gases come from if they are only there when people are respiring.

Q. If those foul, poisonous gases are not eliminated in the act of purification, they do appear in the dwellings when the combustion of the gas takes place? A. No, sir, they do not in any perceptible quantity, for even sulphur appears as sulphurous acid.

Q. Isn't that poisonous? A. Sulphurous acid is a poison only contingently. It does not even destroy the blood-corpuscles, as it is presented to us in our respiration. It partakes of none of the qualities which I have described concerning the truly poisonous gases.

Q. Does it depreciate property? A. I have no doubt of that, because it will tarnish silver. That is not a sanitary question, however; it does not concern hygienists.

Q. Which do you suppose to be the worse, free sulphuretted hydrogen, or sulphide of ammonium free? A. Sulphide of ammonium, far worse.

Q. Have you ever heard of any person being killed by sulphide of ammonium? A. I have known of cases, and they are very numerous; they are known in common life as suffocation and asphyxia.

Q. Occurring under what circumstances? A. Occurring generally in old privies and similar situations; but there are cases which can be referred to as having occurred in a specific manner in gas-works. I need not adduce cases, because they are abundantly verified.

Q. Can there be any sulphuretted hydrogen at all given off by the waste lime, if the prominent odor on opening the purifiers is that of ammonia? A. Yes, sir; I have been present when gas-purifiers were opened and the predominating odor is sulphurous, and the ammonia is dissipated as the men are taking away the lime; and the lime, which I have myself handled twelve hours after it had been thrown out, has grown hot on exposure to the ordinary current of air. One week ago to-day I made the experiment, and the sulphide of ammonium was eliminated in a very offensive and considerable volume, and I was told that the lime had laid nearly twelve hours where it was in a mass; but there was no odor of ammonia there then, but, had I been present at the opening, there would have been an odor of ammonia perceived.

Q. And the odor would have predominated? A. I suppose it would, so far as my senses were concerned; it is one of the most pungent of gases to the senses; it naturally would be predominant.

Q. Notwithstanding all that, and conceding that the predominating odor is that of ammonia, you do think that there may be sulphuretted hydrogen given off by the waste lime? A. I think so; but I have not made exact tests of that question. I believe it is a fact conceded that it is given off.

(No further testimony offered.)

COMPLIANCE OF THE GAS COMPANY WITH THE ORDER OF THE BOARD OF HEALTH.

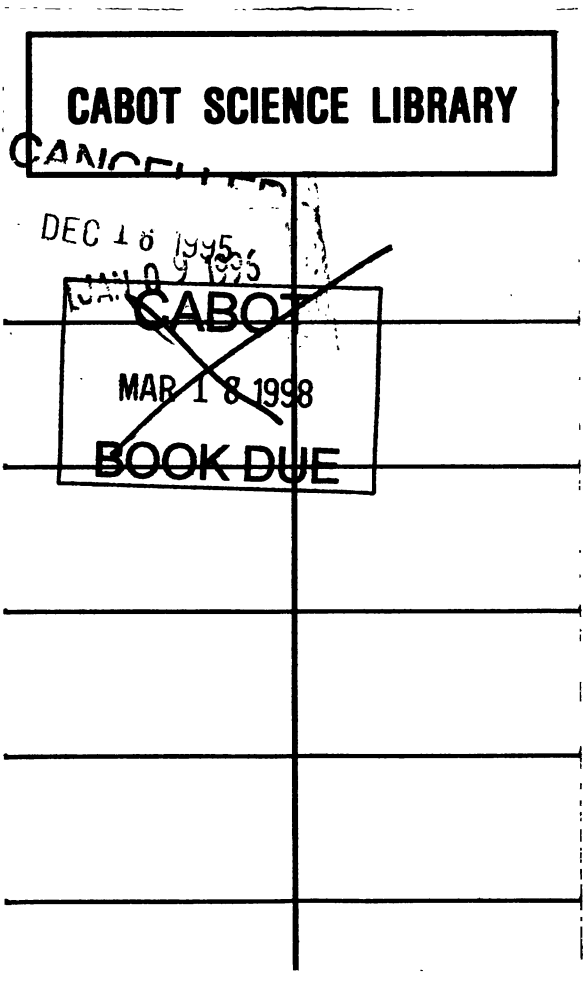
The hearing terminated here, as the Metropolitan Gas-Light Company promised to make the changes necessary to prevent the nuisance complained of.

An iron mixture was used during the summer of 1869, in one set of purifiers; but in the autumn, when the consumption of gas increased, it was thrown out and replaced by lime.

In November the Board ordered the chemist to report *in extenso* on the operations of all the New York Gas Companies. The report will be found on page 5.

When it appeared that the Metropolitan Gas-Light Company was still employing the old process of purification, it was cited to appear by its officers to show cause why the original order of July 14, 1868, should not be enforced. On February 2, 1870, at the earnest request of the officers and counsel of the company, a further respite of three weeks was granted to enable them to introduce the Laming process. On February 23, 1870, the chemist to the Board reported that Laming's process had been introduced, and that it not only gave entire satisfaction to the officers of the company as a purifying process, and made it possible to purify all the gas made, with one set of boxes, two sets having been used for the lime process, but that, as far as he had had an opportunity to observe, it entirely removed the liability to the nuisance which had been so long a cause of complaint against the Metropolitan Gas-Light Company.

The Gas Company has thus complied with the order of the Board of Health, issued July 14, 1868 (page 15), by conducting the process of manufacture so as not to allow deleterious gases and odors, detrimental to health, to escape into the external air.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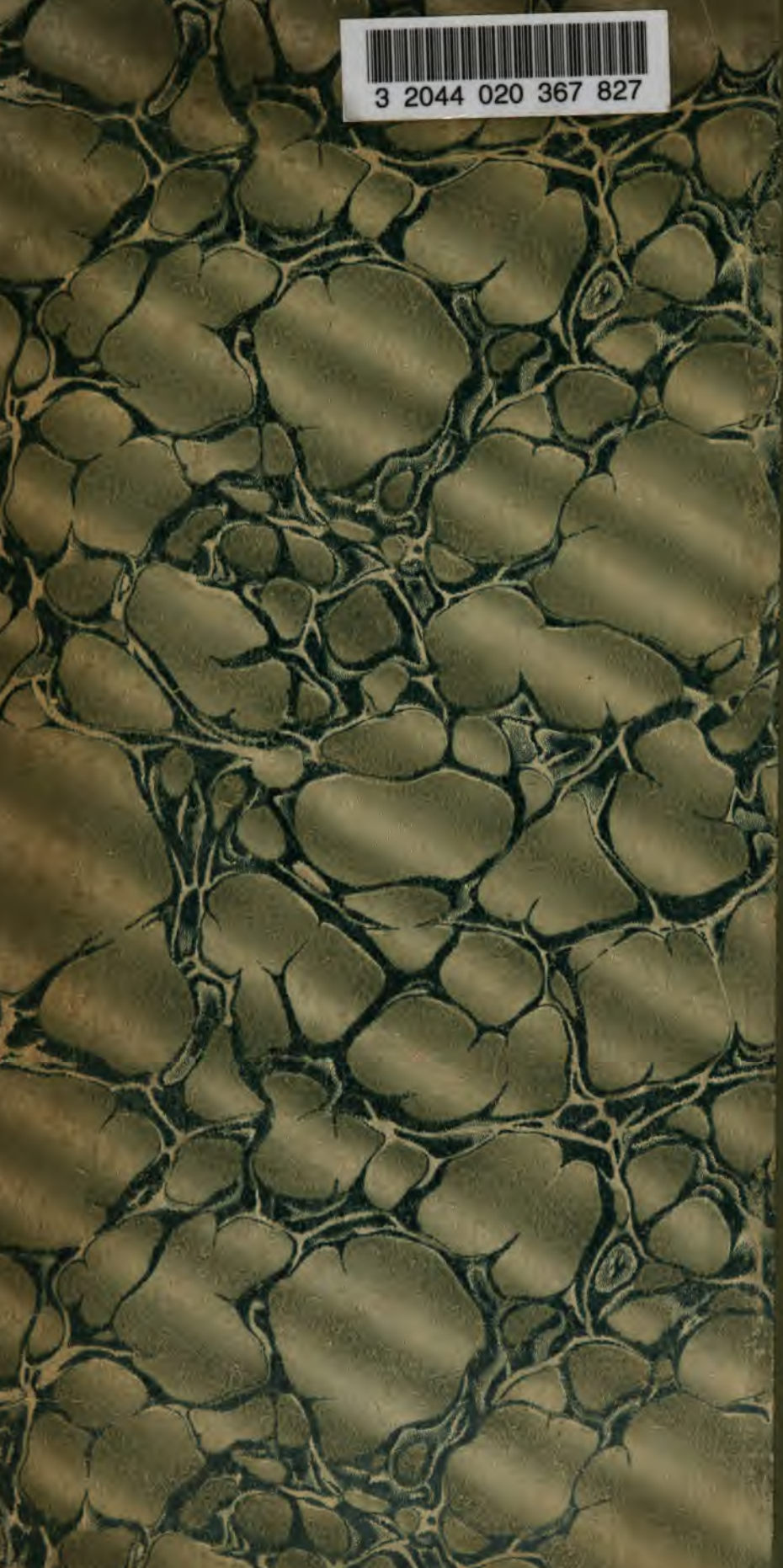
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